

Section 6

Water Demand Projections

6.1 Potable Water Demand Projections

6.1.1 Historic and Current Water Demand per Customer Type

In order to determine the current water demand per customer category, as classified by CESPT, data for the year 2001 and other information provided by CESPT's Customer Data Base, Micrometering, and Water Supply departments was utilized.

According to CESPT's Micrometering Department, the overall water consumption has been decreasing over the last six years, as presented in the table below:

Table 6-1 Historical Consumption per Customer Type (1996-2001)				
Year	Domestic m ³ /dwelling/month	Commercial m ³ /business/month	Industrial m ³ /industry/month	Government m ³ /establishment/month
1996	23	42	378	351
1997	23	43	325	344
1998	21	41	272	332
1999	21	39	279	284
2000	21	36	309	315
2001	19	36	281	259
Source: Micrometering Department, CESPT Commercial Under-Directorate. The values only correspond to customers with metering devices.				

The reduction in water consumption can be attributed to increases in the water rate structure, which could have prompted customers to conserve water. The following sections describe how these values were obtained.

Residential consumption

The overall residential water consumption for users with and without meters for 2001 was obtained by dividing the total invoiced volumes for users with and without meters by the respective number of users, and the current density per dwelling unit (4.12 persons/dwelling unit, INEGI Census 2000), as defined for the study area. With the water consumption values for meters and un-metered users, the weighed average consumption was obtained.

Table 6-2 presents a breakdown of the information utilized and the consumption values for residential users.

Table 6-2 Residential Consumption in 2001		
Concept	Quantity	Unit
Invoiced volume for residential users	60,240,273	m ³ /year
Invoiced volume for residential metered users	52,066,765	m ³ /year
Invoiced volume for residential non-metered users	8,173,508	m ³ /year
Total number of residential accounts	291,216	Accounts
Residential metered accounts	227,501	Accounts
Residential non-metered accounts	63,715	Accounts
% Metered residential volume	86	%
% Non-metered residential volume	14	%
People per dwelling	4.12	people/unit
Metered residential consumption	152	l/capita /day
Non-metered residential consumption	70	l/capita/day
Average consumption (weighted)	131	l/capita/day
Source: Micrometering Department and CESPT's Commercial Under-Directorate		

The current metered consumption is considered to be representative of the future demands as the water service coverage and metering increases to 100 percent of the population. For the purpose of this study, a daily per capita consumption of 152 liters will be used to develop the demand projections. This assumption was validated by the Technical Committee.

Although it is anticipated that the average domestic consumption will increase from 131 to 152 l/capita/day, Section 6.5 presents a series of measures aimed at water conservation and reduction of water losses (physical and commercial), indicating the amount of water that will be saved by the implementation of each of these measures. However, for the purposes of this study, it was agreed with CESPT that only the reduction of physical and commercial water losses resulting from the implementation of such measures would be considered during the development of water demand projections. However, additional savings resulting from other measures and from consumption trends will not be used for the projections, thus resulting in a more conservative scenario. The savings obtained through consumption reduction efforts will be additional to those considered in the planning phase.

Non-residential Consumption

Non-residential consumption is composed of commercial, industrial, and government water users. As indicated in Table 6-1, in 2001 the industrial consumption rate was 281 m³/month per connection, while commercial and government use was 36 and 259 m³/month, respectively.

For the purpose of this study, it was agreed with CESPT that the non-domestic consumption values calculated for the base year (2001), would remain constant

throughout the planning period, as the current consumption is considered to be sufficient to address the needs of this type of customer.

6.1.2 Physical and Commercial Losses (unaccounted-for-water)

Water losses in the conveyance and distribution systems are divided into physical and commercial losses. Physical losses consist of visible and non-visible leaks in the system. This type of losses is accounted for as part of the water supply, but not as part of the actual consumption, as this water never reaches the end user. Commercial losses, on the other hand, represent water flows that were consumed by end users but unaccounted-for and not billed. Commercial losses may consist of illicit connections or connections not registered in the utility's accounting system.

Physical losses

To estimate the water volume associated with physical losses, a study performed for the Playas de Tijuana District in 2000 by CESPT's Operations Department was used. This study is described in greater detail in section 3.3.3. Table 6-3 summarizes the results of this study.

Table 6-3 Water Losses in the Playas de Tijuana District		
	m ³ /month	Percentage
Water production	290,491	100
Water billed	234,999	80.9
Water losses	55,492	19.1
Itemization of Water Losses:		
Identified losses:	14,102	4.9
Physical losses	10,316	3.6
Commercial losses	3,786	1.3
Unidentified losses	41389	14.2
Sources: Operations Control Department (Hydrometering Office, 2001, CESPT).		

The water losses obtained in the aforementioned study are in the order of 19.1 percent, where 14.2 percent corresponds to unidentified losses and 4.9 percent corresponds to identified losses. Identified losses are itemized as follows: physical losses at 3.6 percent and commercial losses at 1.3 percent. The combination of unidentified losses and identified physical losses of the system results in water losses in the order of 17.8 percent of total production. This value is considered acceptable when compared to typical values of other Mexican cities, where physical losses range between 40 to 50 percent (Enríquez, Z.S., Vázquez L.A. y Ochoa A.L., Control de fugas en sistemas de distribución, Manual de diseño de Agua Potable, Alcantarillado y Saneamiento, Comisión Nacional del Agua, 1993).

For the purpose of this study, the value of 17.8 percent for physical losses will be used across the system as no additional information is available. Commercial losses are considered to be the difference between the unaccounted-for-water and the physical losses, explained above. These assumptions were validated by CESPT.

Unaccounted-for-water and commercial losses

The amount of unaccounted-for water was estimated based on existing records from the last six years. From this information, as summarized in Table 6-4, the system's efficiency was calculated.

Table 6-4						
Unaccounted-for-Water for the 1996-2001 Period						
	Year					
	1996	1997	1998	1999	2000	2001
Production (1,000 m ³)	7,014	7,583	7,589	8,356	8,791	8,715
Billing (1,000 m ³)	5,201	5,470	5,670	6,076	6,662	6,667
Unaccounted-for-water (1,000 m ³)	1,813	2,114	1,919	2,280	2,129	2,048
Percentage of unaccounted-for-water	25.6%	27.5%	25.3%	27.3%	24.2%	23.5%
Percentage of physical efficiency	74.4%	72.5%	74.7%	72.7%	75.8%	76.5%
Source: Micrometering Department – CESPT Commercial Under-Directorate, 2002.						

Figure 6-1 depicts the behavior of the percentage of unaccounted-for-water curve (global losses) for the last six years.

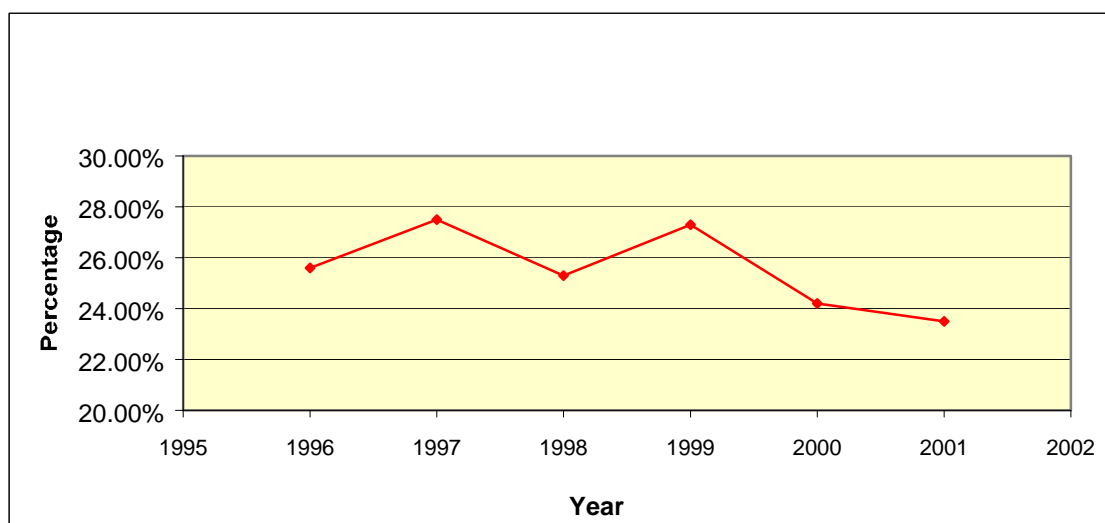


Figure 6-1
Unaccounted for Water 1996-2001 Tijuana and Playas de Rosarito

According to the figure above, unaccounted-for-water shows a decreasing trend during the last three years, recording a minimum value of 23.5 percent in 2001. This reduction can be attributed to the leak detection and elimination program implemented by CESPT. Furthermore, the utility anticipates that by 2005, unaccounted-for-water will be further reduced to 20 percent (subsection 6.1.4).

As previously mentioned, assuming that the percentage of water losses observed in the Playas de Tijuana District study (17.8 percent) is representative of the entire system, it could be inferred that commercial losses were in the order of 5.7 percent in 2001.

For the purpose of this study, global losses of 23.5 percent for the base year (2001) will be utilized. Global losses will be divided into physical losses (17.8 percent) and commercial losses (5.7 percent). Thus, the physical efficiency for 2001 is 76.5 percent, which will be utilized for calculating the current water supply requirements for all customer categories.

6.1.3 Current Water Supply per Customer Type

Water supply is composed of actual water consumption plus physical water losses. With the current water demand and global physical efficiency figures obtained in previous sections, the water supply needs per customer type were calculated as summarized below.

Table 6-5 Water Supply per User Type (2001)	
Customer Type	Supply
Residential	171 l/capita/d
Commercial	47 m ³ /business/month
Industrial	363 m ³ /industry/month
Government	335 m ³ /establishment/month

6.1.4 Future Physical and Commercial Losses

CESPT has made the commitment to CNA and CEA to increase its global efficiency to at least 78 percent by 2004, in order to have access to a Japanese credit that will be used for expansion of various water supply and wastewater collection and treatment projects. This commitment implies a reduction in the percentage of unaccounted-for-water down to 22 percent. Nonetheless, CESPT has set the goal to reduce global losses to 20 percent by 2008, and maintain it at that level for the long term.

Therefore, for the development of this master plan the physical and commercial losses presented in Table 6-6 are used.

Table 6-6 Projected Physical and Commercial Water Losses				
Concept	Year			
	2002 (%)	2003 (%)	2004 (%)	2008 – 2023 (%)
Physical water losses	17.8	17.8	17.0	17.0
Commercial water losses	5.7	5.7	5.0	3.0
Global water loss	23.5	23.5	22.0	20.0
Global physical efficiency	76.5	76.5	78.0	80.0

As shown in the table, current global losses will decrease from the current 23.5 percent to 20 percent by the year 2004 as a result of the loss reduction programs currently being implemented by CESPT. After 2004, losses will be reduced 0.5 percent per year until they reach 20 percent by 2008, and will remain constant afterward.

To achieve this loss reduction goal and the proposed efficiency levels, a permanent program for leak detection and leak repair, line replacement, and lining of water tanks is being implemented. With this initiative it is expected to reduce physical losses from 17.8 percent in 2003 to 17.0 percent in 2004. Additionally, commercial losses will be reduced from 5.7 percent in 2003 to 3.0 percent in 2005 through the implementation of a program to detect, regulate and eliminate illegal water connections. In Section 6.5 these measures and their expected outcome are presented in more detail.

6.1.5 Water Consumption and Supply Projections

This section describes the methodology employed to project water demands and the most relevant results of this exercise. In Appendix O, the model employed for the development of water demand and wastewater generation projections is presented.

Consumption projections

As previously indicated, the current average residential consumption (for 2001) is 131 l/capita/day, while the consumption for customers with metered connections is 152 l/capita/day. It is considered that a consumption value of 152 l/capita/day shall be sufficient to satisfy the water needs of an individual. Therefore, it was agreed for the purpose of developing water demand projections to gradually increase the average water consumption figure to 152 l/capita/day from 2002 to 2005, as shown on Table 6-7.

For commercial, industrial and government customers, it is considered that the current water consumption levels (Table 6-5) meet the needs of these users, and consequently it was agreed to maintain them constant during the planning period. It is further considered that new businesses to be established in the study area will have similar characteristics in terms of water consumption to existing customers.

Table 6-7 presents future demands considered in this study for each type of customer.

Table 6-7 Water Demand Projections					
Customer Type	Unit	Year			
		2002	2003	2004	2005 - 2023
Residential	(l/capita/day)	141	145	149	152
Commercial	(m ³ /business/month)	36	36	36	36
Industrial	(m ³ /industry/month)	277	277	277	277
Government	(m ³ /establishment/month)	256	256	256	256

Supply projections

Based on the consumption and global efficiency projections, the future supply was determined, as summarized in the table below.

Table 6-8 Water Supply Projections					
Customer Type	Unit	Year			
		2002	2003	2004	2005 - 2023
Domestic	(l/capita/day)	184	190	191	190
Commercial	(m ³ / business/month)	47	47	46	45
Industrial	(m ³ /industry/month)	363	363	355	346
Governmental	(m ³ /establishment/month)	335	335	328	320

6.1.6 Water Demand Projections

The demand projections were made for the average daily flow, as well as for the maximum daily flow. The maximum daily flow will be compared to the infrastructure capacity of the water production (wells, treatment plants, etc.), given that these should have sufficient capacity to cover the demands. In subsequent sections the proposed facilities will be sized based on the maximum daily demand. The maximum daily demand calculation is made by means of the application of a 1.2 factor to the average daily demand.

In order to project the future demand it was necessary to determine the population (see Section 5) in each city, as well as the transient population that appears in Playas de Rosarito in vacation and summer periods that demand the same potable water and wastewater services as the permanent residents.

It was under this context that research was made in the compiled documents for the percentage and quantity of population that is present in Playas de Rosarito during periods of vacation and stays moer than one night in that city and its southern extremities.

According to the Programa de Desarrollo Urbano de Centro de Población de Playas de Rosarito, B.C. 2000 (PDUCPPR), developed by the municipal government, the transient population in this city in 2001 corresponded to 17 percent of the total population. Additionally, the Plan de Desarrollo Urbano del Centro de Población de Tijuana (PDUCPT) estimates, based on SEDESOL figures, that the transient population is approximately 38.7 percent of the permanent population for the year 2000.

Finally, the Proposal for Water Supply for the Municipalities of Tijuana and Playas de Rosarito in the Short-Term 2000-2010 (Propuesta de Abastecimiento de Agua Potable a los Municipios de Tijuana y Playas de Rosarito, B.C. de Corto Plazo 2000-2010), prepared in 1996 by CNA, estimates a transient population of 25.5 percent in relation to the permanent population for the year 2000.

After assessing the different procedures utilized in each of the studies previously mentioned, it was decided to use a factor of 25 percent to estimate the transient population of Playas de Rosarito.

Once future supply, permanent and transient population projections, and projections for commercial, industrial and governmental users, were obtained, water demand projections by user type were developed.

The criteria used for the development of permanent population projections and for the projection of the number of commercial, industrial and governmental establishments were presented in Section 5. Table 6-9 shows the transient population projected for Playas de Rosarito and other coastal communities, as well as the population projections for the municipalities of Tijuana and Playas de Rosarito within the study area.

Table 6-9 Population Projections						
Total Municipal Population			Population within the Study Area			
Year	Tijuana	Playas de Rosarito	City of Tijuana	City of Playas de Rosarito and Coastal Communities	Transient Population in Playas de Rosarito and Coastal Communities	Total
2001	1,270,092	68,679	1,263,742	66,756	16,689	1,347,187
2002	1,309,296	72,147	1,302,750	70,127	17,532	1,390,409
2003	1,349,711	75,790	1,342,962	73,668	18,417	1,435,047
2004	1,391,373	79,377	1,384,416	77,154	19,289	1,480,859
2005	1,434,321	83,133	1,427,149	80,805	20,201	1,528,155
2006	1,475,127	87,068	1,467,751	84,629	21,157	1,573,537
2007	1,517,093	91,188	1,509,508	88,635	22,159	1,620,302
2008	1,560,253	95,504	1,552,452	92,830	23,208	1,668,490
2009	1,604,642	99,790	1,596,619	96,996	24,249	1,717,864
2010	1,650,293	104,268	1,642,042	101,348	25,337	1,768,727
2011	1,694,936	108,948	1,686,461	105,897	26,474	1,818,832
2012	1,740,787	113,837	1,732,083	110,650	27,663	1,870,396
2013	1,787,878	118,946	1,778,939	115,616	28,904	1,923,459
2014	1,836,243	123,826	1,827,062	120,359	30,090	1,977,511
2015	1,885,917	128,906	1,876,487	125,297	31,324	2,033,108
2016	1,930,763	134,195	1,921,109	130,438	32,610	2,084,157
2017	1,976,676	139,700	1,966,793	135,788	33,947	2,136,528
2018	2,023,680	145,432	2,013,562	141,360	35,340	2,190,262
2019	2,071,802	151,398	2,061,443	147,159	36,790	2,245,392
2020	2,121,068	157,610	2,110,463	153,197	38,299	2,301,959
2021	2,165,929	164,076	2,155,099	159,482	39,871	2,354,452
2022	2,211,739	170,807	2,200,680	166,024	41,506	2,408,210
2023	2,258,517	177,815	2,247,224	172,836	43,209	2,463,269
2030	2,636,594	231,577	2,623,411	225,093	56,273	2,904,777
2040	3,195,576	324,957	3,179,598	315,858	78,965	3,574,421

As shown in the table, the total population within the study zone will increase from 1,347,187 in 2003 to 2,463,269 in 2023, which represents an additional 83 percent of the current population. Furthermore, for the year 2040 that the population will reach 3,574,421 people, which represents a 165 percent increase from the 2001 population.

Table 6-10 presents the projections for commercial, industrial and government customers to be established within the study area.

Table 6-10			
Projections for Commercial, Industrial and Government Customers			
Year	Commercial	Industrial	Governmental
2001	18,670	2,439	1,098
2002	19,246	2,514	1,132
2003	19,840	2,591	1,167
2004	20,453	2,671	1,203
2005	21,183	2,767	1,246
2006	21,786	2,846	1,281
2007	22,406	2,926	1,317
2008	23,043	3,010	1,355
2009	23,698	3,095	1,394
2010	24,492	3,199	1,440
2011	25,154	3,286	1,479
2012	25,835	3,374	1,519
2013	26,534	3,466	1,560
2014	27,251	3,559	1,602
2015	28,131	3,674	1,654
2016	28,800	3,762	1,694
2017	29,485	3,851	1,734
2018	30,186	3,943	1,775
2019	30,904	4,037	1,817
2020	31,819	4,156	1,871
2021	32,492	4,244	1,911
2022	33,179	4,334	1,951
2023	33,881	4,425	1,992
2030	39,879	5,208	2,345
2040	49,937	6,391	2,877

As indicated in the table above, the number of commercial establishments will grow from 18,670 in 2001 to 33,881 in 2023; the industrial users will increase from 2,439 to 4,425 in the same period; and the governmental users will increase from 1,098 to 1,992.

Finally, the water demand can be estimated by multiplying the population, commercial, industrial, and government projections by their respective supply needs, for each year during the entire planning horizon. Table 6-11 presents the total water demand projection for Tijuana and Playas de Rosarito, including the communities of Primo Tapia, Puerto Nuevo and Santa Anita. Water demand projections used for the remaining of the master plan include the demand exerted by the transient population.

Table 6-11 Water Demand Projections by User Type for Tijuana, Playas de Rosarito and Coastal Communities (l/s)						
Year	Residential	Commercial	Industrial	Governmental	Average Daily Demand	Maximum Daily Demand
2001	2,495	336	341	142	3,347	3,977
2002	2,814	346	352	146	3,658	4,390
2003	2,988	357	363	151	3,859	4,631
2004	3,176	361	367	152	4,056	4,867
2005	3,322	365	370	154	4,211	5,053
2006	3,434	375	381	158	4,348	5,218
2007	3,550	386	391	163	4,490	5,388
2008	3,669	397	403	167	4,636	5,563
2009	3,778	408	414	172	4,772	5,726
2010	3,890	422	428	178	4,918	5,902
2011	4,000	433	440	183	5,056	6,067
2012	4,113	445	451	188	5,197	6,236
2013	4,230	457	464	193	5,344	6,413
2014	4,349	469	476	198	5,492	6,590
2015	4,471	484	492	204	5,651	6,781
2016	4,583	496	503	209	5,791	6,949
2017	4,698	507	515	214	5,934	7,121
2018	4,817	520	528	219	6,084	7,301
2019	4,938	532	540	225	6,235	7,482
2020	5,062	548	556	231	6,397	7,676
2021	5,178	559	568	236	6,541	7,849
2022	5,296	571	580	241	6,688	8,026
2023	5,417	583	592	246	6,838	8,206
2030	6,391	686	697	290	8,064	9,677
2040	7,865	842	855	356	9,918	11,902

As indicated in the table above, the water demand will increase from 3,347 in 2001 to 6,838 l/s in 2023, which represents an increase of 106 percent with respect to the current demand. For the year 2040, the required flow will reach 9,918 l/s.

Figure 6-2 depicts the behavior of the total water demand curve for the planning period from 2001 to 2023.

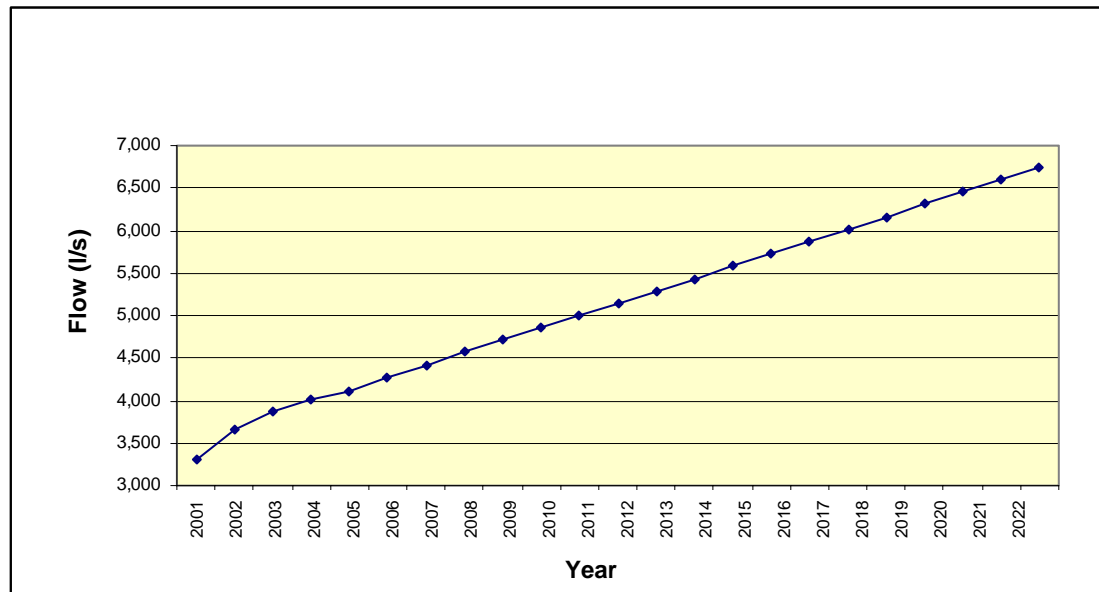


Figure 6-2
Total Water Demand for the Study Area (Annual average)

The demand curve behavior is somewhat different in the first few years, from 2001 to 2004, due to the variations expected in the domestic consumption and the global physical efficiency, as previously mentioned.

6.1.7 Comparison Between Water Demand and Capacity of Water Supply Sources

In order to determine when the current water supply sources will be depleted and will no longer be able to meet the water consumption needs, current supply sources at maximum capacity were compared with the projected water demand throughout the planning period.

It is important to point out that water production is limited not only by the capacity of the sources, but also by the configuration and capacity of the conveyance, distribution and treatment infrastructure. The capacity of this infrastructure is analyzed in Section 6.1.8, while this section discusses the capacity of the sources independently of the capacity of the existing infrastructure.

Groundwater sources (Wells)

The CESPT system has 15 wells, but only a few are in operation. The wells are distributed in three aquifers: Tijuana-Alamar, La Misión, and Playas de Rosarito. Currently, the wells located in the Tijuana-Alamar aquifer supply approximately 73 l/s, although pump tests indicate that the aquifer has the capacity to sustain production for up to 430 l/s. The La Misión wells operate at the aquifer's estimated maximum yield, supplying 51 l/s. Finally, the Playas de Rosarito wells are currently out of service as a result of salt-water intrusion. These wells are not expected to operate in the future. In 2001, the Playas de Rosarito wells supplied a flow of 22 l/s.

CESPT has plans to rehabilitate the Tijuana-Alamar wells in order to fully utilize the aquifer maximum capacity (430 l/s according to CESPT's well tests), starting in 2003 and extending throughout the planning period. However, it is important to point out that a detailed study is necessary to confirm that this extraction rate can be achieved and sustained.

Abelardo L. Rodríguez Reservoir

The Abelardo Rodríguez Reservoir represents a secondary water source. The reservoir is recharged primarily by local stormwater runoff, which is limited in the study area. For planning purposes the reservoir is not considered as a permanent water supply source, and it is estimated that it will be used only during significant precipitation events, as occurred in 1993-1998. When rainfall events result in significant storage volumes in the reservoir, CESPT may utilize this water, replacing in some instances the total flow supplied by the Colorado River Aqueduct, which has a high operational cost as a result of pumping requirements. During winter months CESPT takes advantage of reduced electricity rates to convey and store Colorado River water in the reservoir. Water stored in this reservoir is subsequently treated at the Abelardo L. Rodríguez Water Treatment Plant and conveyed to the distribution system. In 2001, the reservoir provided a flow of 36 l/s.

Colorado River-Tijuana Aqueduct

This aqueduct conveys surface water from the Colorado River to the El Carrizo Reservoir, from which water is conveyed to Tijuana and Playas de Rosarito. As described in Section 3, the aqueduct has six pumping stations that pump water to an elevation of 1,060 meters above mean sea level. From the El Carrizo Reservoir water is conveyed by gravity in two lines to the El Florido Water Treatment Plant. Furthermore, water stored in El Carrizo can be conveyed to the Abelardo L. Rodríguez Reservoir.

According to information provided by CESPT, this water source currently supplies an average flow of 3,900 l/s, equivalent to its maximum capacity. About 180 l/s are conveyed to the city of Tecate. Additionally, it is estimated that about 10 percent of the flow is lost during conveyance and also due to evaporation at the El Carrizo Dam. The flow that reaches Tijuana and Playas de Rosarito is 3,330 l/s.

CESPT has plans to increase the flow supplied by this source through the rehabilitation and reinforcement of the existing aqueduct, which would increase its conveyance capacity by 1,300 l/s starting in 2008. Approximately, 10 percent of those 1,300 l/s would be lost due to conveyance and storage, yielding a net flow of 4,500 l/s for Tijuana and Playas de Rosarito by the time the rehabilitation works are completed.

San Diego Emergency Connection

Currently an emergency water connection with a capacity of 600 l/s allows the transmission of water from the San Diego County Water Authority to Tijuana during extraordinary events. However, there is an agreement that allows Tijuana access to this source on a permanent basis during five years, starting in 2003 through 2008, while the Colorado River- Tijuana Aqueduct is rehabilitated.

Table 6-12 presents the projected water demand and the supply capacity of all water sources.

Table 6-12 Projected Demand and Capacity of Existing Sources							
Source	Capacity (l/s)						
	2001	2003	2008	2013	2023	2030	2040
Colorado River –Tijuana Aqueduct	3,330	3,330	4,500	4,500	4,500	4,500	4,500
Tijuana-Alamar Wells	73	430	430	430	430	430	430
La Misión Wells	51	51	51	51	51	51	51
Playas de Rosarito Wells	22	-	-	-	-	-	-
Abelardo L. Rodríguez Reservoir	36	-	-	-	-	-	-
Emergency Connection	-	600	600	-	-	-	-
Total Supply	3,512	4,411	5,581	4,981	4,981	4,981	4,981
Total Demand (average day)	3,347	3,859	4,636	5,344	6,838	8,064	9,918
Surplus (average day)	-	552	945	-	-	-	-
Deficit (average day)	-	-	-	363	1,857	3,083	4,937
Total Demand (maximum day)	3,977	4,631	5,563	6,413	8,206	9,677	11,902
Surplus (average day)	-	-	-	-	-	-	-
Deficit (average day)	465	220	582	1,432	3,225	4,696	6,921

Starting in 2002 the flows from the Playas de Rosarito aquifer and the Abelardo L Rodríguez Reservoir are not considered, as the wells are, and will continue to be, out of service as a result of salt water intrusion, while the reservoir is not a permanent source.

Figure 6-3 shows the demand projection and the supply capacity. It can be seen that existing sources will cover average demand until to 2012. After this year, new water sources will be required. Alternatives for addressing the expected deficit are presented in Section 7.

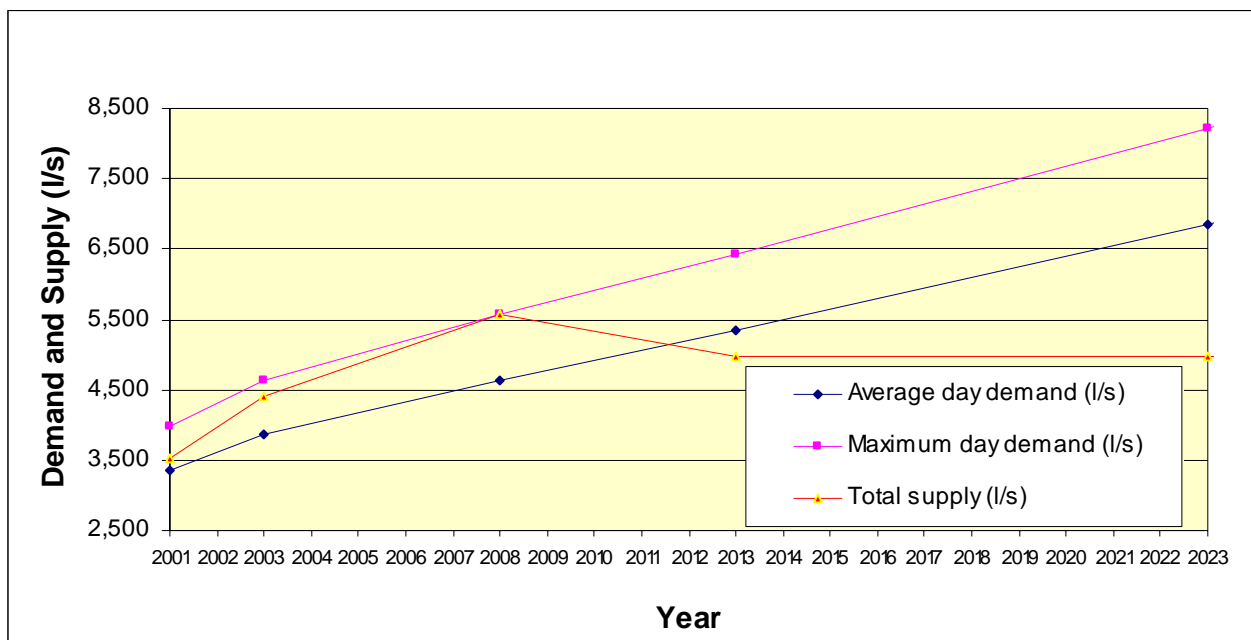


Figure 6-3
Water Supply and Demand Projections

6.1.8 Comparison of Water Demand Capacity

In addition to the rehabilitation and expansion of the existing water supply sources, it is necessary to have the treatment infrastructure required to provide water of sufficient quality and quantity, taking into consideration the raw water quality and the Mexican drinking water standards for human consumption.

The water system includes two water treatment plants, El Florido and Abelardo L. Rodríguez, with a capacity of 4,000 and 600 l/s, respectively,. However, the Rodríguez Plant only operates occasionally, as it only treats the relatively small flows that originate in the basin of the Rodríguez Reservoir.

Additionally, a new water treatment plant is currently under construction to treat raw water from the Tijuana – Alamar aquifer. The plant will have a treatment capacity of 250 l/s and will be in operation in 2003. It is anticipated that of the 430 l/s that are extracted from this aquifer, 233 l/s will be treated at the new plant, while the remaining 197 l/s will continue being chlorinated in the wells without further treatment.

Table 6-13 presents the flows that will require treatment, as well as the projected needs for treatment infrastructure.

Table 6-13 Water Demand Projections and Treatment Capacity									
Maximum Day Demand (l/s)			Year						
			2001	2003	2008	2013	2023	2030	2040
			3,977	4,631	5,563	6,413	8,206	9,677	11,902
Water Supply (l/s)	Colorado River-	Capacity	3,330	3,330	4,500	4,500	4,500	4,500	4,500
	Tijuana Aqueduct	Requires treatment	3,330	3,330	4,500	4,500	4,500	4,500	4,500
	Tijuana-Alamar Wells	Capacity	73	430	430	430	430	430	430
		Requires treatment	-	233	233	233	233	233	233
	La Misión Wells	Capacity	51	51	51	51	51	51	51
		Requires treatment	-	-	-	-	-	-	-
	Rodríguez Reservoir	Capacity	36	-	-	-	-	-	-
		Requires treatment	36	-	-	-	-	-	-
	Emergency Connection	Capacity	-	600	600	-	-	-	-
		Requires treatment	-	-	-	-	-	-	-
Flow that does not require treatment (l/s)			124	848	248	248	248	248	248
Treatment Requirements (l/s)			3,853	3,783	5,315	6,165	7,958	9,429	11,654
Existing Treatment Capacity (l/s)			4,600	4,850	4,850	4,850	4,850	4,850	4,850
Treatment Deficit (l/s)					-465	-1,315	-3,108	-4,579	-6,804

Figure 6-4 presents the behavior of the projected treatment demand and infrastructure capacity requirements. It can be seen that the demand will be satisfied until 2013, after which time it will be necessary to increase the treatment capacity to satisfy the demand and overcome the shortfall of subsequent years, which could reach up to 3,108 l/s in 2023 and 6,804 l/s in 2040 (Section 7 presents a proposed solution to meet this demand).

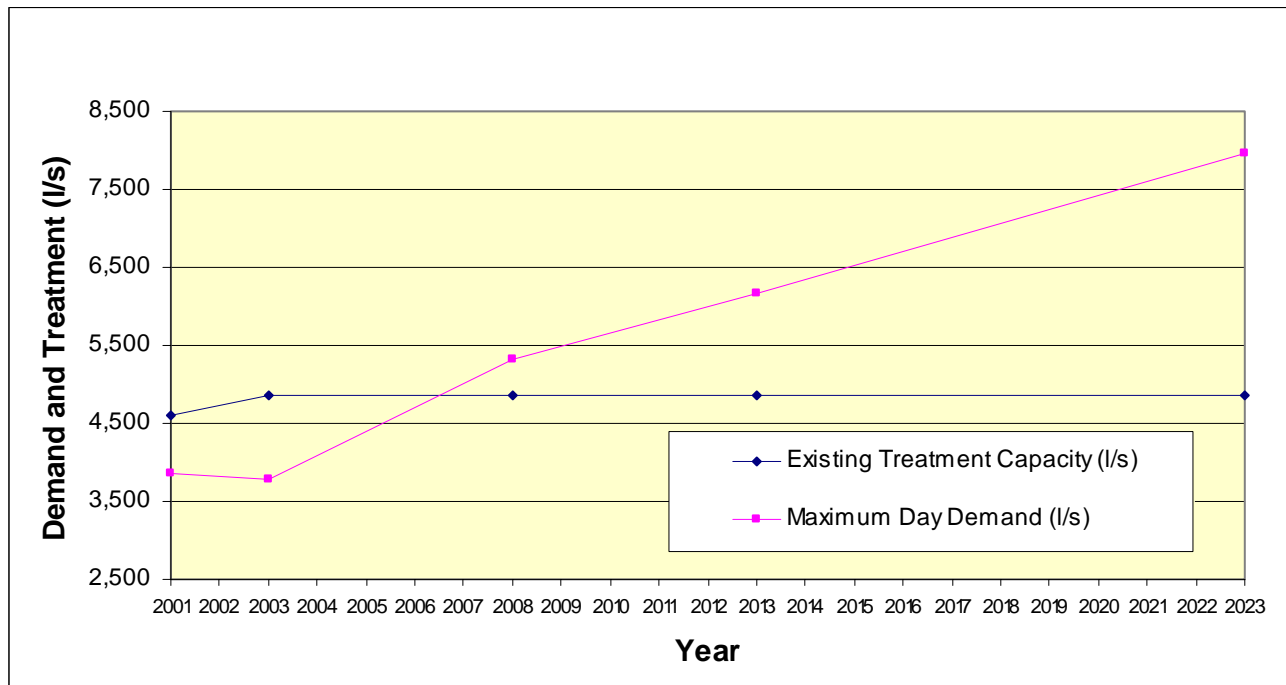


Figure 6-4
Projected Water Treatment Demand
and Existing Treatment Capacity

6.2 Wastewater Flow Projections

As indicated in Section 6.1.6, the drinking water needs of the area are expected to increase rapidly during the planning period. Furthermore, as a result of the increase in water consumption, wastewater generation will also increase, resulting in the need for new wastewater collection, conveyance and treatment facilities. Wastewater flows are projected in this section and compared to existing treatment capabilities.

This subsection demonstrates wastewater flow projections and analyzes the current and future sewage system capacity to cover the required demands. As opposed to the potable water system, the projected generation of wastewater in comparison to the wastewater capacity will be made only for the average daily flow.

Appendix O presents a detailed water demand and wastewater generation model.

6.2.1 Current Wastewater Generation

Wastewater flow measurements recorded in 2001 by CESPT indicate that in that year an average flow of 2,358 l/s was measured in the sewer system, as summarized in Table 6-14.

Table 6-14 Wastewater Flow Measurements- 2001	
Measuring Point	Measured Flow (l/s)
International Wastewater Treatment Plant (WWTP)	1,052
San Antonio WWTP	899
San Antonio WWTP bypass	366
Rosarito WWTP	37
Del Mar San Antonio del Mar WWTP	2
Puerto Nuevo WWTP	2
Total	2,358
Source: CESPT (Sub-dirección de Saneamiento), 2001	

It is estimated that of the total flow, 175 l/s correspond to the Alamar and Matanuco flows (140 and 35 l/s, respectively) that are intercepted and conveyed to the treatment facilities. Thus, the differential of 2,183 l/s corresponds to the wastewater flow intercepted by the sewer system, including infiltration but excluding flows from the arroyos Alamar and Matanuco.

6.2.2 Sewer System Infiltration

In general, sewer systems receive flows from infiltration and other sources such as manholes. Infiltration flows tend to be more significant for sewer lines installed below the water table or within surface water channels. It is presumed that the most susceptible areas to water infiltration in Tijuana are zones located in the lower elevations and areas near surface streams such as the Alamar and Tijuana rivers. Infiltration flows are conveyed along with wastewater flows to pump stations and wastewater treatment plants, and are therefore, accounted during sewer flow measurements.

As previously discussed, the average wastewater flow in 2001 was 2,202 l/s, excluding the flow from the Alamar and Matanuco arroyos. The water consumption in areas that have access to drinking water was estimated at 2,292 l/s. The typical value of consumed water that returns to the sewer system as wastewater is 85 percent. If the typical contribution value of 85 percent is applied, a wastewater flow equivalent to 1,949 l/s is obtained. The difference between the measured wastewater flow (2,183 l/s), excluding the arroyos' flows, and the generated wastewater flow (2,202 l/s), yields an infiltration flow of 253 l/s, which represents a 12 percent of the system flow, excluding the flow of the arroyos. The infiltration flow including the intercepted flow from the arroyos is 409 l/s, which represents 21 percent of the measured flow.

It is assumed that the infiltration rate will gradually decrease from 12 to 8 percent by the year 2006 as a result of the sewer system rehabilitation program. Additionally, it is assumed that the flow of the arroyos will remain constant during the planning

period and that these flows will continue to be intercepted by the pump stations and conveyed to the wastewater treatment plants.

6.2.3 Projections of Wastewater Generation

Based on the percentages of water consumed that becomes wastewater, infiltration, and flows from the Alamar and Matanuco arroyos, wastewater generation rates were projected. These flows will have to be collected, conveyed, and treated, taking as a basis the water consumption estimated in Section 6.1.5.

Table 6-15 presents wastewater generation projections for the study area, from the current base year (2001) through 2040.

Table 6-15 Wastewater Generation Projections (2001-2023)							
	Year						
	2001	2003	2008	2013	2023	2030	2040
Water consumption in sewerage areas (l/s)	2,315	2,864	3,635	4,259	5,676	6,693	8,232
Wastewater generation as % of water consumption	85	85	85	85	85	85	85
Wastewater generation (l/s)	1,968	2,435	3,089	3,620	4,824	5,689	6,997
Infiltration including arroyos (l/s)	409	443	422	465	561	630	735
Wastewater generation including infiltration and arroyos	2,377	2,878	3,511	4,085	5,385	6,319	7,732

6.2.4 Comparison of Wastewater Generation and Treatment Capacity

Wastewater treatment will be limited by the current and future capacity of the wastewater treatment plants. Information provided by CESPT and utilized in this analysis include the Rehabilitation and Sanitation of the Tijuana River Study (1995), which contemplates the rehabilitation and expansion of existing facilities, and the construction of new plants.

There are currently five wastewater treatment plants in the study area that are operated by CESPT (see Table 6-16) with a combined treatment capacity of 1,904 l/s (2001). In addition, according to information provided by the Technical Department of CNA's State Division of Baja California, there are 86 private wastewater treatment plants (54 in Tijuana and 32 in Rosarito), mostly serving industrial customers and some residential areas. These private treatment facilities have a combined capacity of 326 l/s. Portion of the treated effluent of these plants is reused to irrigate landscaped areas and the remainder is discharged into the sewer system. However, for the

comparison of wastewater flow projections with the treatment capacity, presented in Table 6-17, it is assumed that the capacity of these plants is negligible, since these plants are out of the control of the CESPT and the amount of effluent from these plants that is discharged to the sewer system and that needs to be re-treated at the CESPT plants is not known.

Table 6-16 presents the existing and future wastewater treatment facilities and the year in which they are expected to start operation.

Table 6-16 Treatment Capacity of Existing and Projected Plants					
Plant		Current capacity (year 2001) (l/s)	Future capacity (l/s)	Year to start operation	Type of project required
Existing Treatment Plants	International Plant	1,100	1,100	-	-
	San Antonio de los Buenos (Punta Bandera)	750	1,100	2003	Rehabilitation
	Rosarito	50	50	-	-
	San Antonio del Mar	2.5	2.5	-	-
	Puerto Nuevo	1.5	1.5	-	-
	Sub-Total	1,904	2,254		
Plants to be constructed under the Japanese Credit	Tecolote-La Gloria	-	380	2005	Construction of new plant
	Monte de los Olivos	-	460	2005	Construction of new plant
	La Morita	-	380	2005	Construction of new plant
	Lomas de Rosarito	-	210	2005	Construction of new plant
	Subtotal		1,430		
Total		1,904	3,684	-	-

Source: Sub-dirección de Saneamiento, CESPT, 2001.

The table above indicates an existing treatment capacity of 1,904 l/s. However, it is anticipated that by the year 2005 new facilities will be in place, with a new treatment capacity of 2,254 l/s in the year 2003, and up to 3,684 l/s starting in 2005. Table 6-17 presents the treatment needs or demand and the capacity of the treatment system.

Table 6-17 Wastewater Flow Projections and Treatment Capacity							
	Year						
	2001	2003	2008	2013	2023	2030	2040
Wastewater generation (l/s)	2,377	2,878	3,512	4,085	5,385	6,319	7,732
Treatment capacity (l/s)	1,904	2,254	3,684	3,684	3,684	3,684	3,684
Surplus (+) or Deficit (-)	-473	-624	172	-401	-1,701	-2,635	-4,048

Table 6-17 indicates that in case that no new plants are constructed in addition to those included in the Japanese credit, there will be a considerable treatment capacity deficit practically during the entire planning horizon. In subsequent sections possible solutions to this situation are presented.

Figure 6-5 shows the behavior of the wastewater treatment needs and the installed infrastructure capacity curve.

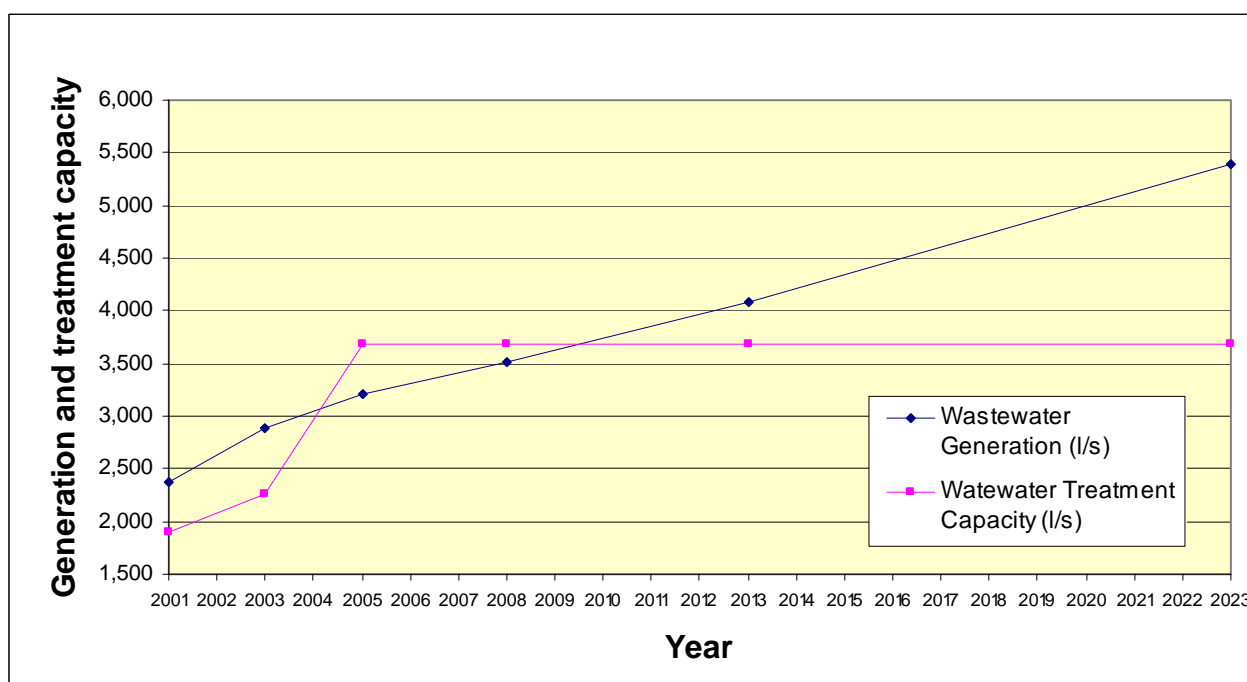


Figure 6-5
Wastewater Treatment Demand and Capacity

As shown in the figure above, in 2001 there was a deficit in the treatment capacity of 473 l/s. Although the treatment capacity will increase in 2003, it will continue to be insufficient to meet the treatment needs. With the startup of the satellite plants in 2005, constructed through the Japanese credit program, the treatment demand will be temporarily met until the year 2009, after which time it will be necessary to increase the treatment capacity, otherwise the treatment deficit would soar up to 1,701 l/s in 2023 and 4,048 l/s in 2040.

6.3 Water Demand Geographical Distribution

Upon completion of the population projections, potable water demand projections and wastewater demand projections at a global level, it becomes necessary to distribute geographically both population and flows, using either pressure zones for the case of water, or sewerhed in the case of wastewater. This geographic distribution will later be used in the sizing of the proposed infrastructure.

6.3.1 Definition of Pressure Zones

The global water demands previously presented were distributed geographically using as a basis the location of tanks and their zones of influence for both present and future service areas. For the future growth areas described in Section 5, the zones of influence for future tanks were delineated based on topography and the projected location of such service areas.

Water supply and distribution in Tijuana and Playas de Rosarito is achieved by means of two main aqueducts: La Misión-Tijuana and Aguaje de la Tuna, which are fed by the La Misión wells and the Colorado River Aqueduct. For the definition of the pressure zones, 81 of the 183 storage tanks were considered. These are the tanks that provide the most important storage capacities, which vary from 1,000 to 30,000 m³. Table 6-18 lists the 81 storage tanks, while Figure 6-6 shows the areas of influence and defines the pressure zones in which the system is divided. In Section 3, Table G-4, a list of all storage tanks is presented. Information available for each tank includes physical condition, type, elevation, capacity, year of construction, and size.

The division of the system into pressure zones is defined by the lack of interconnections among the zones, or by the presence of isolation valves between zones. However, these valves can be utilized during emergency situations to supply water from one to another zone.

The definition of the pressure zones within the current distribution system was established by CESPT. On the other hand, the definition of influence zones in areas of future growth, which partly depends on the water supply alternatives is explained in Section 10.

Table 6-18 presents a list of the 81 existing pressure zones, an additional pressure zone for areas of future growth, and the demand exerted by the transient population of Playas de Rosarito. It is important to point out that this demand is distributed along the coastal area comprised by the rural communities of the municipality, the city of Playas de Rosarito, and in existing and future urban areas. The location of the tanks necessary to meet future needs is based on the results of the hydraulic model is presented in section 10.

Figure 6-6 shows the areas that are presently (2001) connected to the water supply system. The areas that do not have potable water will be integrated to tanks that due to their locations, capacity, and elevation can supply water that meets pressure requirements, as per the Mexican norm.

The creation of pressure zones from 2001 through 2023 will be defined according to urban sprawl, population density, site topography, and existing physical barriers that limit their service areas, as prescribed in the Development Plans of Tijuana and Playas de Rosarito.

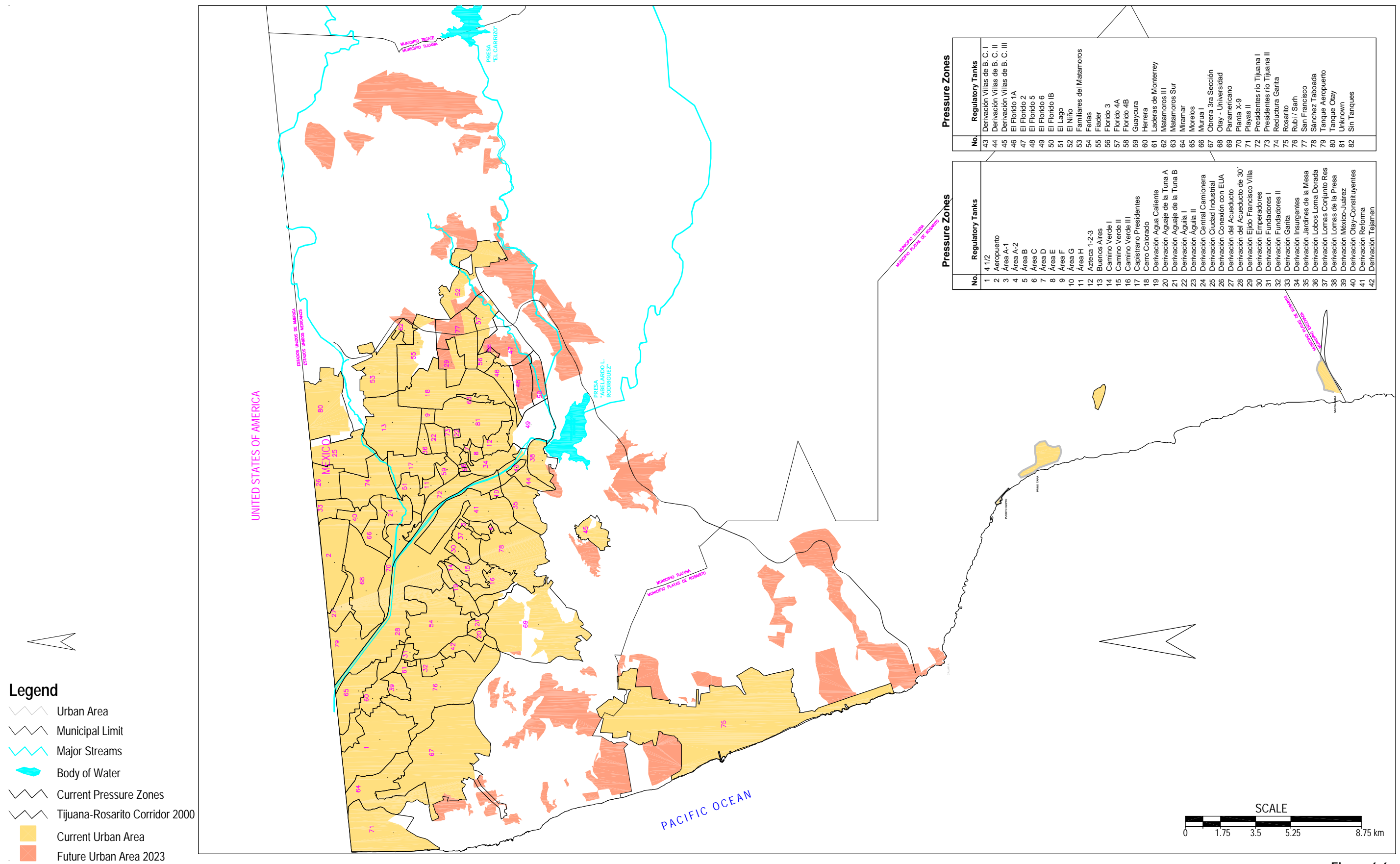


Table 6-18
Large Storage Capacity Tanks (1,000 to 30,000 m³)

1	4 ½	29	Diversion Point: Ejido Francisco Villa	57	Florida 4 ^a
2	Aeropuerto	30	Diversion Point: Emperadores	58	Florida 4B
3	Area A-1	31	Diversion Point: Fundadores I	59	Guaycura
4	Área A-2	32	Diversion Point: Fundadores II	60	Herrera
5	Área B	33	Diversion Point: Garita	61	Laderas de Monterrey
6	Área C	34	Diversion Point: Insurgentes	62	Matamoros III
7	Área D	35	Diversion Point: Jardines de la Mesa	63	Matamoros Sur
8	Área E	36	Diversion Point: Lobos Loma Dorada	64	Miramar
9	Área F	37	Diversion Point: Lomas Conjunto Residencial	65	Morelos
10	Área G	38	Diversion Point: Lomas de la Presa	66	Murua I
11	Área H	39	Diversion Point: México-Juárez	67	Obrera 3ra Sección
12	Azteca 1-2-3	40	Diversion Point: Otay-Constituyentes	68	Otay - Universidad
13	Buenos Aires	41	Diversion Point: Reforma	69	Panamericano
14	Camino Verde I	42	Diversion Point: Tejaman	70	Planta X-9
15	Camino Verde II	43	Diversion Point: Villas de Baja California I	71	Playas II
16	Camino Verde III	44	Diversion Point: Villas de Baja California II	72	Presidentes río Tijuana I
17	Capistrano Presidentes	45	Diversion Point: Villas de Baja California III	73	Presidentes río Tijuana II
18	Cerro Colorado	46	El Florido 1 ^a	74	Reductora Garita
19	Diversion Point: Agua Caliente	47	El Florido 2	75	Rosarito
20	Diversion Point: Aguaje de la Tuna A	48	El Florido 5	76	Rubi / Sarh
21	Diversion Point: Aguaje de la Tuna B	49	El Florido 6	77	San Francisco
22	Diversion Point: Águila I	50	El Florido IB	78	Sánchez Taboada
23	Diversion Point: Águila II	51	El Lago	79	Tanque Aeropuerto
24	Diversion Point: Central Camionera	52	El Niño	80	Tanque Otay
25	Diversion Point: Ciudad Industrial	53	Familiares del Matamoros	81	Unknown
26	Diversion Point: Conexión con EUA	54	Ferías	-	No tanks*
27	Diversion Point: of Acueducto	55	Fiader	-	Seasonal population (Playas de Rosarito) **
28	Diversion Point: of Acueducto de 30'	56	Florida 3		

*Future zones that do not have storage reservoirs.

**Population that requires service only in high season in Playas de Rosarito.

Source: Water Department. Sub-dirección de Operación y Mantenimiento CESPT, 2001.

6.3.2 Population Distribution by Pressure Zones

The distribution of the global population, either for current or future conditions, was accomplished through the development of a series of polygons that cover the urban area, either current or future. Each polygon has its own attributes relative to location, surface area, and population densities. These characteristics allow to estimate population within each polygon, and therefore, for the entire city.

For current conditions, the polygons were created using as a basis the Basic Statistics Geographical Areas (AGEB, Spanish acronym) that are presented in the XII Census of

Population and Housing (INEGI 2000). The census presents relevant information on each AGEB, such as population and surface area. The 2000 population obtained from the census was distributed per AGEB. For 2001, the 2000-defined AGEB were used to create additional polygons for currently developed areas not included in the census. The density for each polygon, either AGEB or new polygon, was defined for the year 2001 from the Census 2000 results and from land use plans within the study area. The population was later distributed as a function of each polygon's location, size, and density. This process was repeated for the years 2008, 2013, and 2023.

Industrial and commercial users were geographically distributed for present condition based on two criteria, approved by CESPT: (1) That 50 percent of the industries registered with CESPT for 2001 are located within industrial parks, while the rest are scattered throughout the city in areas not defined for industrial use in the land use and zoning plans of the city; (2) That 20 percent of the commercial users are concentrated within commercial areas, while the remaining 80 percent are located throughout the urban area. Lastly, government users were proportionally distributed according to the population of each area.

For future conditions, it was assumed that the distribution criteria for industrial users would continue to be valid, since the land use plans contemplate the creation of industrial districts similar to the existing ones. For commercial users, however, it was assumed that the future distribution would be proportional to the population, as the land use plans do not contemplate the creation of commercial districts. Lastly, the criteria utilized for distribution of government users under current conditions will be used for future conditions as well.

Once the pressure zones were defined and population and non-residential users projections were distributed among the polygons that comprise the study area, the population of each polygon was assigned to the corresponding pressure zone by means of a GIS-based computer model.

Table 6-19 presents the population by pressure zone for the years 2001, 2008, 2013, and 2023. Figure 6-7 present the land use of each large-capacity tank influence zone.

Table 6-19 Population Distribution by Storage Tank (Pressure Zones) -2001					
No.	Tank	Population			
		2001	2008	2013	2023
1	4 ½	70,999	75,340	76,573	77,314
2	Aeropuerto	44	24	15	7
3	Área A-1	3,688	3,972	4,144	4,405
4	Área A-2	892	731	622	458
5	Área B	509	635	724	884
6	Área C	554	667	746	891
7	Área D	3,898	4,193	4,403	4,808
8	Área E	3,295	3,368	3,419	3,515
9	Área F	3,706	4,689	5,325	6,221
10	Área G	2,080	2,532	2,732	2,948
11	Área H	1,124	1,252	1,342	1,514
12	Azteca 1-2-3	7,997	10,068	11,526	13,894
13	Buenos Aires	30,112	40,927	46,644	52,526
14	Camino Verde I	9,695	11,582	12,519	13,787
15	Camino Verde II	15,126	17,341	17,846	18,276
16	Camino Verde III	14,168	19,071	19,864	20,971
17	Capistrano Presidentes	15,436	15,745	15,912	15,742
18	Cerro Colorado	76,931	92,470	98,190	104,647
19	Derivación Agua Caliente	5,270	5,958	6,367	6,934
20	Derivación Aguaje de la Tuna A	1,521	1,868	1,930	1,953
21	Derivación Aguaje de la Tuna B	1,489	2,089	2,452	2,918
22	Derivación Águila I	3,682	4,785	5,552	6,838
23	Derivación Águila II	1,778	1,694	1,695	1,695
24	Derivación Central Camionera	8,986	10,376	10,940	11,710
25	Derivación Ciudad Industrial	3,857	3,967	4,275	4,927
26	Derivación Conexión con EUA	17,921	18,902	19,089	19,161
27	Derivación del Acueducto	16,184	16,270	15,706	14,536
28	Derivación del Acueducto de 30´	48,255	51,016	52,182	54,263
29	Derivación Ejido Francisco Villa	24,760	28,774	30,604	32,429
30	Derivación Emperadores	5,835	7,360	8,145	9,132
31	Derivación Fundadores I	1,764	1,992	2,152	2,451
32	Derivación Fundadores II	2,803	2,875	2,924	3,019
33	Derivación Garita	660	623	597	549
34	Derivación Insurgentes	7,323	8,025	8,691	10,056
35	Derivación Jardines de la Mesa	17,340	21,382	23,940	28,264
36	Derivación Lobos Loma Dorada	7,782	11,641	13,275	14,851
37	Derivación Lomas Conjunto Residencial	7,711	8,397	8,760	9,151
38	Derivación Lomas de la Presa	9,261	11,446	12,943	14,124
39	Derivación México-Juárez	8,477	8,531	8,394	8,045
40	Derivación Otay-Constituyentes	3,812	3,926	3,998	4,117
41	Derivación Reforma	38,077	40,607	41,516	42,783
42	Derivación Tejamen	9,380	10,430	10,905	11,567
43	Derivación Villas de Baja California I	748	1,135	1,334	1,518
44	Derivación Villas de Baja California II	12,175	13,174	13,833	14,932
45	Derivación Villas de Baja California III	6,948	8,664	10,190	12,518
46	El Florido 1A	14,516	16,284	17,021	18,103
47	El Florido 2	2,624	33,114	25,659	49,516
48	El Florido 5	1	1	25,924	30,806
49	El Florido 6	1,901	2,249	2,453	2,754
50	El Florido IB	0	0	0	380
51	El Lago	12,373	15,036	16,640	18,770
52	El Niño	29,390	31,633	39,455	64,331

Table 6-19 Population Distribution by Storage Tank (Pressure Zones) -2001					
No.	Tank	Population			
		2001	2008	2013	2023
53	Familiares del Matamoros	21,158	33,005	38,486	45,197
54	Ferías	26,494	24,919	24,584	24,898
55	Fiader	34,466	43,233	42,306	47,246
56	Florido 3	4,558	4,698	4,786	4,936
57	Florido 4A	18,404	23,214	25,516	44,817
58	Florido 4B	813	9,986	10,000	9,999
59	Guaycura	5,676	6,235	6,609	7,270
60	Herrera	28,792	30,385	30,737	31,184
61	Laderas de Monterrey	185	165	152	127
62	Matamoros III	3,123	4,705	5,587	7,521
63	Matamoros Sur	4,426	4,614	4,711	4,828
64	Miramar	23,699	23,776	24,295	25,073
65	Morelos	19,826	22,183	23,078	24,569
66	Murua I	6,660	7,221	7,580	8,252
67	Obrera 3ra Sección	48,233	59,444	66,328	75,168
68	Otay - Universidad	45,298	45,263	45,239	45,304
69	Panamericano	23,991	32,409	36,547	42,215
70	Planta X-9	14,957	16,156	16,942	18,337
71	Playas II	32,542	37,852	41,461	47,329
72	Presidentes río Tijuana I	1,639	1,577	1,538	1,483
73	Presidentes río Tijuana II	10,120	10,417	10,360	10,175
74	Reductora Garita	28,664	30,374	31,263	32,545
75	Rosarito	57,929	81,269	100,814	146,935
76	Rubí / Sarh	68,775	70,409	70,298	69,512
77	San Francisco	32,365	69,452	61,450	77,867
78	Sánchez Taboada	47,875	54,130	54,568	54,752
79	Tanque Aeropuerto	22,793	23,292	23,236	22,636
80	Tanque Otay	28,372	35,440	38,809	45,195
81	Unknown	12,339	10,644	10,733	11,493
s/n	Sin Tanques*	61,468	119,984	264,451	561,288
s/n	Población Flotante (Playas de Rosarito)**	16,689	23,208	28,903	43,208
Total		1,347,187	1,668,490	1,923,454	2,463,268
*Future areas without regulation tanks.					
**Population demanding service in vacation periods in Playas de Rosarito.					

Legend

- Urban Area
- Municipal Limit
- Major Streams
- Body of Water
- Current Pressure Zones
- Tijuana-Rosarito Corridor 2000
- Current Urban Area
- Future Urban Area 2023
- Current Industrial Area
- Current Commercial Area
- Future Industrial Area 2023

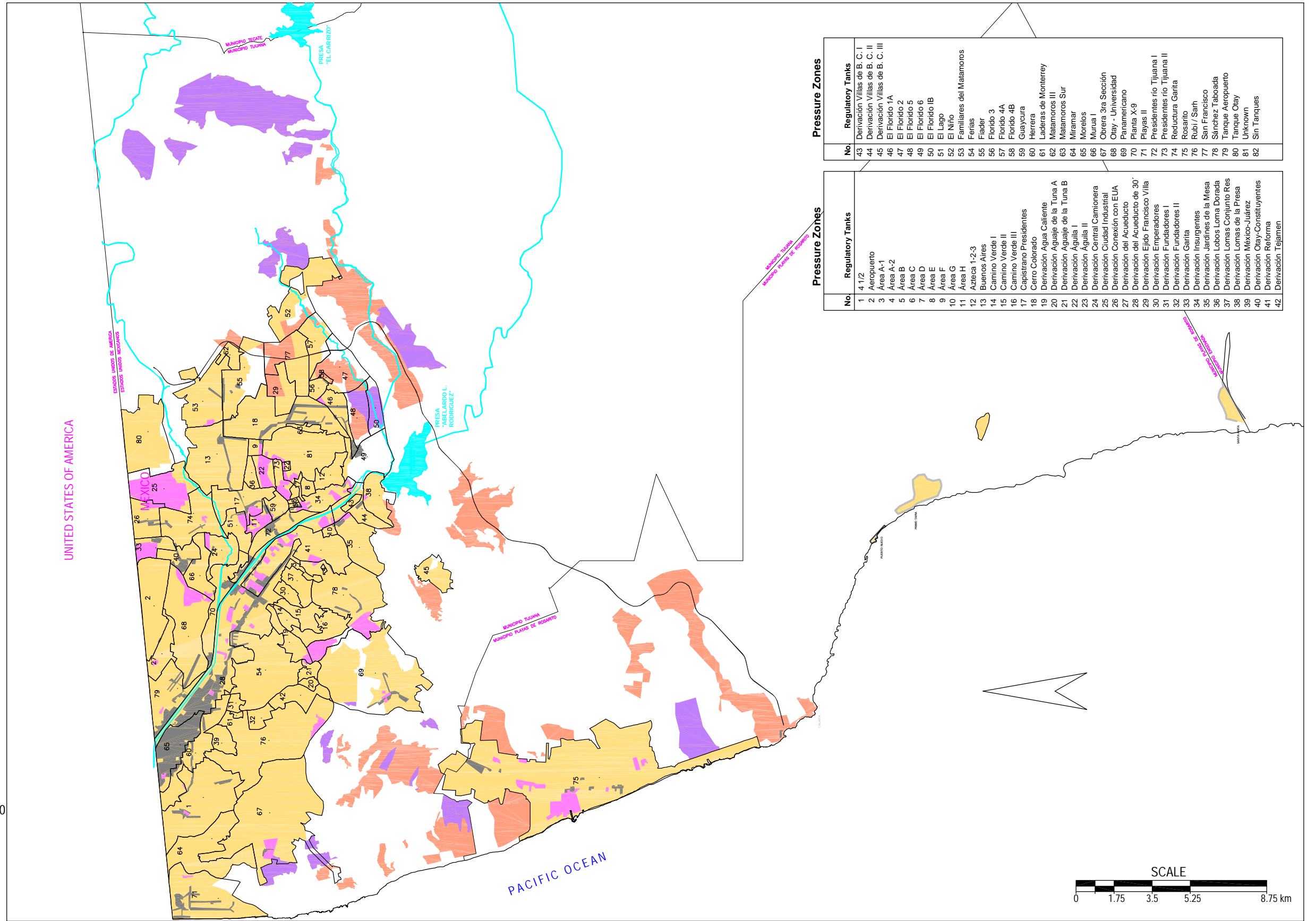


Figure 6-7
Landuse within each Pressure Zone

6.3.3 Water Demand Distribution by Pressure Zone

In Section 6.1, water consumption, supply, and losses were defined for the different types of customers (see Table 6-1). For determining the current and future water demand for each pressure zone, average supply values were assigned to, and the water demands were added up for each customer type. Table 6-20 and Figure 6-8 present the water demand per customer type for the years 2001, 2008, 2013, and 2023.

The demand projection for each pressure zone was developed with the use of a simple model which allows the user to make changes associated with water demand distribution for the various time periods through 2023. Appendix O presents the model used to estimate demands by tank area for each period.

No.	Storage Tank	Water demand average day (l/s)				Water demand maximum day (l/s)			
		2001	2008	2013	2023	2001	2008	2013	2023
1	4 ½½	167	200	204	207	200	240	245	248
2	Aeropuerto	1	1	1	1	1	1	1	1
3	Área A-1	8	10	11	12	10	12	13	14
4	Área A-2	2	2	2	1	2	2	2	1
5	Área B	1	2	2	2	1	2	2	2
6	Área C	1	2	2	2	1	2	2	2
7	Área D	9	11	12	13	11	13	14	16
8	Área E	8	9	9	9	10	11	11	11
9	Área F	9	12	14	16	11	14	17	19
10	Área G	5	7	7	8	6	8	8	10
11	Área H	3	3	3	4	4	4	4	5
12	Azteca 1-2-3	19	26	30	37	23	31	36	44
13	Buenos Aires	71	109	124	140	85	131	149	168
14	Camino Verde I	22	31	33	36	26	37	40	43
15	Camino Verde II	35	45	47	48	42	54	56	58
16	Camino Verde III	33	50	52	55	40	60	62	66
17	Capistrano Presidentes	38	43	44	43	46	52	53	52
18	Cerro Colorado	181	245	261	278	217	294	313	334
19	Derivación Agua Caliente	14	17	18	20	17	20	22	24
20	Derivación Aguaje de la Tuna A	3	5	5	5	4	6	6	6
21	Derivación Aguaje de la Tuna B	4	6	7	8	5	7	8	10
22	Derivación Águila I	12	16	18	22	14	19	22	26
23	Derivación Águila II	4	4	4	4	5	5	5	5
24	Derivación Central Camionera	22	29	30	33	26	35	36	40
25	Derivación Ciudad Industrial	36	37	38	39	43	44	46	47
26	Derivación Conexión con EUA	44	52	52	53	53	62	62	64
27	Derivación del Acueducto	38	43	42	39	46	52	50	47
28	Derivación del Acueducto de 30'	145	166	169	175	174	199	203	210
29	Derivación Ejido Francisco Villa	57	76	80	86	68	91	96	103
30	Derivación Emperadores	13	19	21	24	16	23	25	29

Table 6-20
Water Demand per Storage Tank (Pressure Zones)

No.	Storage Tank	Water demand average day (l/s)				Water demand maximum day (l/s)			
		2001	2008	2013	2023	2001	2008	2013	2023
31	Derivación Fundadores I	4	5	6	6	5	6	7	7
32	Derivación Fundadores II	6	8	8	8	7	10	10	10
33	Derivación Garita	8	7	7	7	10	8	8	8
34	Derivación Insurgentes	19	23	25	29	23	28	30	35
35	Derivación Jardines de la Mesa	40	56	63	75	48	67	76	90
36	Derivación Lobos Loma Dorada	18	31	35	39	22	37	42	47
37	Derivación Lomas Conjunto Residencial	18	22	23	24	22	26	28	29
38	Derivación Lomas de la Presa	22	30	34	38	26	36	41	46
39	Derivación México-Juárez	20	22	24	21	24	26	29	25
40	Derivación Otay-Constituyentes	10	12	14	12	12	14	17	14
41	Derivación Reforma	101	118	117	125	121	142	140	150
42	Derivación Tejamén	22	27	29	31	26	32	35	37
43	Derivación Villas de Baja California I	2	3	3	4	2	4	4	5
44	Derivación Villas de Baja California II	28	35	36	39	34	42	43	47
45	Derivación Villas de Baja California III	16	23	27	33	19	28	32	40
46	El Florido 1A	34	44	46	49	41	53	55	59
47	El Florido 2	6	87	67	131	7	104	80	157
48	El Florido 5	0	0	68	81	0	0	82	97
49	El Florido 6	7	9	9	10	8	11	11	12
50	El Florido IB	9	8	8	9	11	10	10	11
51	El Lago	32	43	48	53	38	52	58	64
52	El Niño	68	83	104	170	82	100	125	204
53	Familiares del Matamoros	50	87	102	120	60	104	122	144
54	Ferías	63	67	66	67	76	80	79	80
55	Fiader	80	114	112	125	96	137	134	150
56	Florido 3	11	18	19	22	13	22	23	26
57	Florido 4A	43	61	67	118	52	73	80	142
58	Florido 4B	2	26	26	26	2	31	31	31
59	Guaycura	13	17	18	19	16	20	22	23
60	Herrera	69	82	83	85	83	98	100	102
61	Laderas de Monterrey	0	0	0	0	0	0	0	0
62	Matamoros III	7	12	15	20	8	14	18	24
63	Matamoros Sur	10	12	12	13	12	14	14	16
64	Miramar	55	63	64	66	66	76	77	79
65	Morelos	60	72	75	79	72	86	90	95
66	Murua I	16	20	21	23	19	24	25	28
67	Obrera 3ra Sección	121	165	184	208	145	198	221	250
68	Otay - Universidad	112	126	126	126	134	151	151	151
69	Panamericano	59	89	100	116	71	107	120	139
70	Planta X-9	36	44	46	50	43	53	55	60
71	Playas II	80	104	114	130	96	125	137	156
72	Presidentes río Tijuana I	6	6	6	6	7	7	7	7
73	Presidentes río Tijuana II	24	28	28	27	29	34	34	32

Table 6-20 Water Demand per Storage Tank (Pressure Zones)									
No.	Storage Tank	Water demand average day (l/s)				Water demand maximum day (l/s)			
		2001	2008	2013	2023	2001	2008	2013	2023
74	Reductora Garita	67	81	83	87	80	97	100	104
75	Rosarito	141	220	272	395	169	264	326	474
76	Rubi / Sarh	168	194	194	192	202	233	233	230
77	San Francisco	75	182	162	205	90	218	194	246
78	Sánchez Taboada	132	162	164	165	158	194	197	198
79	Tanque Aeropuerto	56	64	64	63	67	77	77	76
80	Tanque Otay	67	95	104	121	80	114	125	145
81	Desconocido	34	33	34	36	41	40	41	43
s/n	Sin Tanques (futuro)	160	364	774	1,619	192	437	929	1943
s/n	Población Flotante (Playas de Rosarito)	31	51	64	95	37	61	77	114
Total *		3,343	4,633	5,342	6,838	4,012	5,560	6,410	8,206
Note: The demand presented in the table considers the population of Tijuana and Playas de Rosarito, as well as 25% of the transient population in Playas de Rosarito									

Please note that there is a small difference between the total global demand and the geographically distributed demands. This small variation, which is not significant, is due to the rounding off in the distribution of customers of each polygon once the users have been divided into the pressure zones in which each polygon is located and the addition of the transient population of Rosarito. Section 10 presents water distribution by tank area.

Legend

- Urban Area
- Municipal Limit
- Major Streams
- Body of Water
- Current Pressure Zones
- Tijuana-Rosarito Corridor 2000
- Current Urban Area
- Future Urban Area 2023

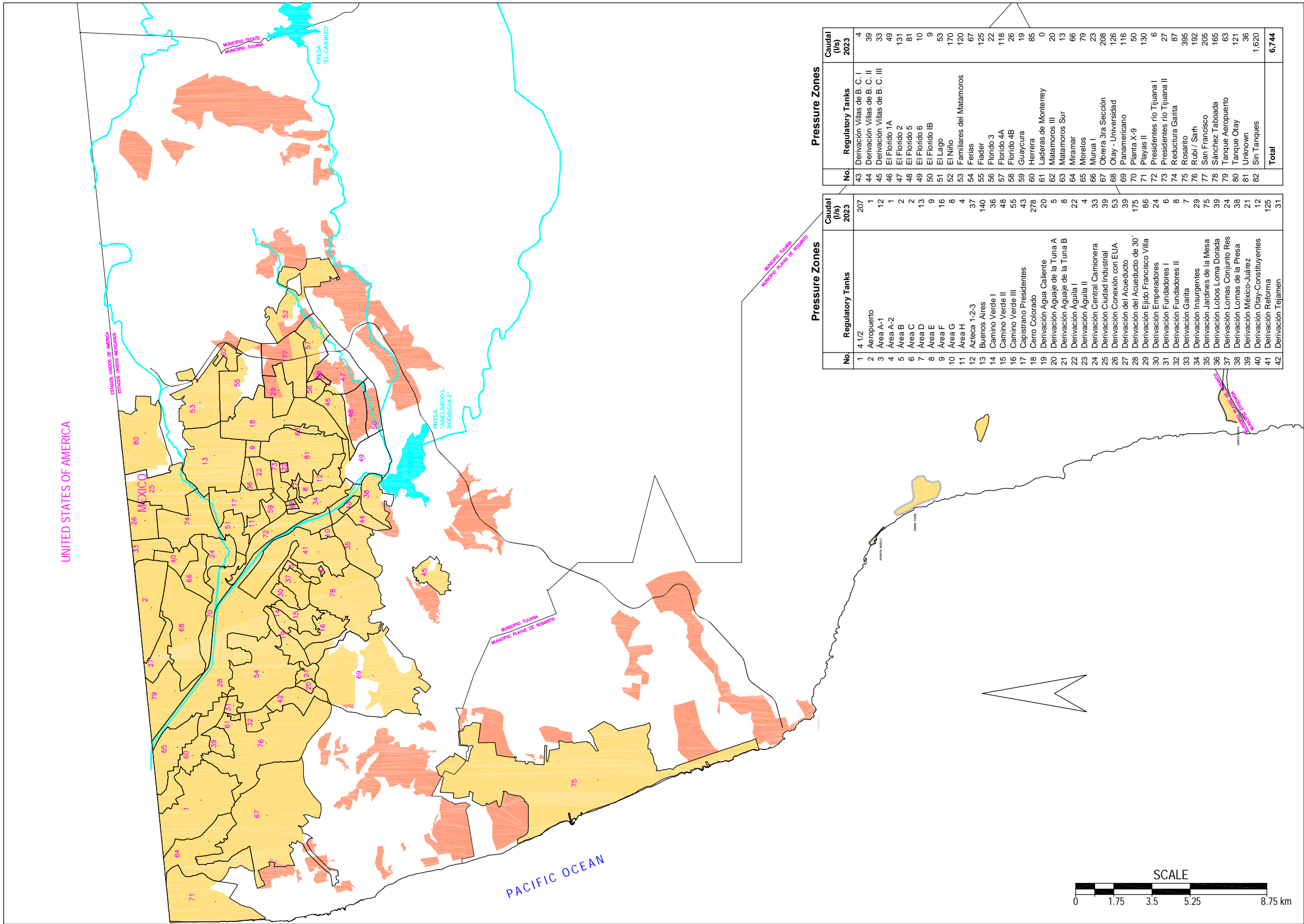


Figure 6-8
Cost Distribution per Pressure Zone

6.4 Geographical Distribution of Wastewater Generation Projections

The methodology utilized for the geographical distribution of wastewater generation projections is very similar to the one used in the water demand distribution, with the exception that the number of customers for each polygon is distributed by sewer sub-basins instead of by water pressure zones. The methodology employed in this exercise and the most relevant results are presented below.

6.4.1 Definitions of Sewer Sub-basins

The study area can be divided, based on its topography, into the Tijuana River watershed, which flows toward the United States and where most of the population of the study area resides, and in a series of micro watersheds that flow directly toward the Pacific Ocean, located along the coastline. Figure 6-9 depicts the location of these natural drainage areas.

The Tijuana River watershed and the coastline watersheds can in turn be subdivided into 39 sub-basins, with the purpose of evaluating the sewer system and to propose solutions and alternatives. Table 6-21 lists the sub-basins, while Figure 6-9 shows their limits and geographical distribution.

In the study area sewer system there are 27 collectors and sub-collectors, 2 interceptors, and 2 force mains that discharge into the three existing wastewater treatment plants. Based on the location of these infrastructure elements, the sub-basins can be further subdivided into 131 drainage basins.

For future conditions, the new collectors and sub-collectors will be integrated, as necessary, to the present sewer system to convey wastewater to the existing and future wastewater treatment plants.

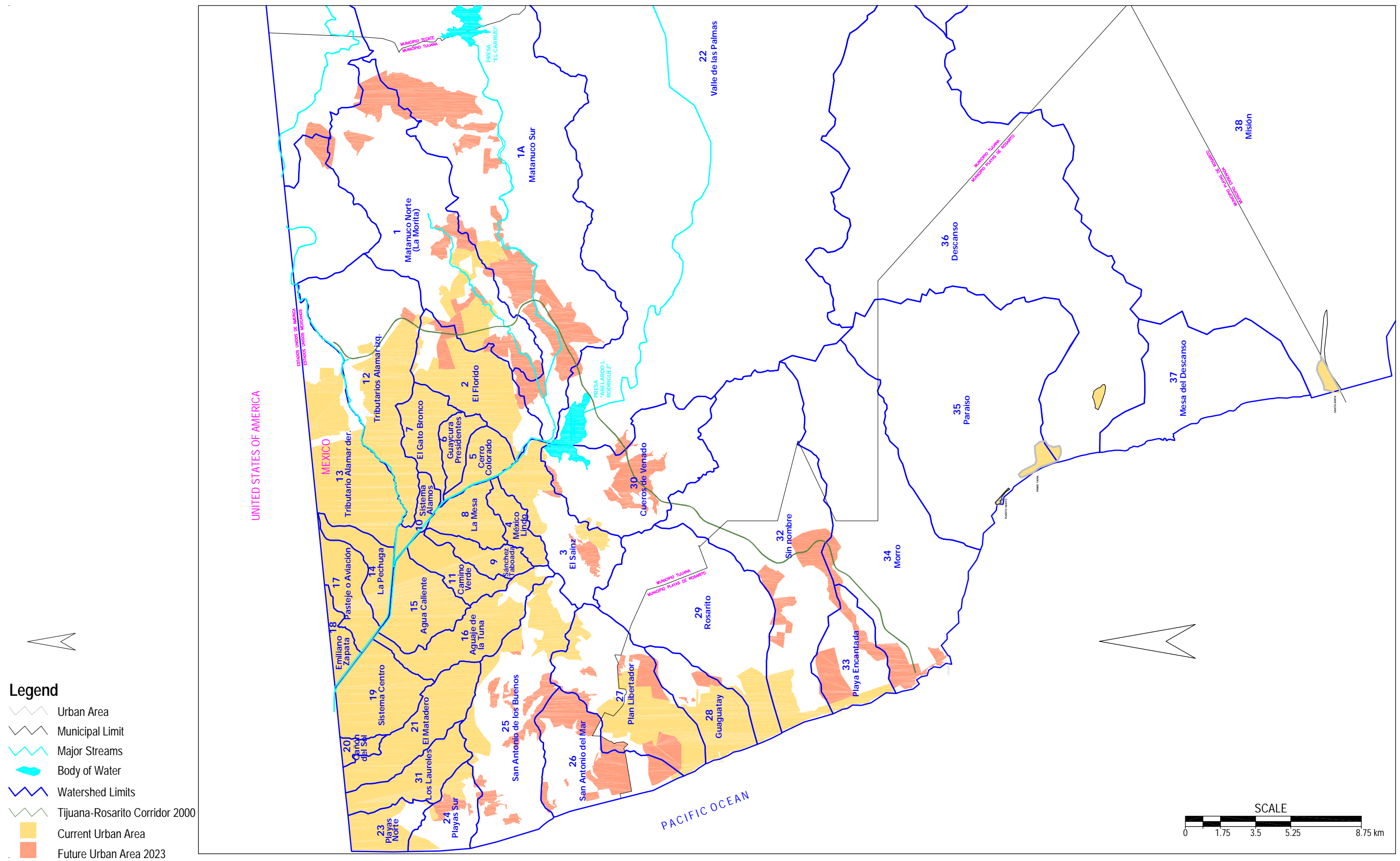


Figure 6-9
Watershed Limits

Table 6-21 Sub-basin within the Study Area			
1	Matanuco Norte (La Morita)	20	Cañón del Sol
1a	Matanuco Sur	21	El Matadero
2	El Florido	22	Valle de las Palmas
3	El Sainz	23	Playas Norte
4	México Lindo	24	Playas Sur
5	Cerro Colorado	25	San Antonio de Los Buenos
6	Guaycura Presidentes	26	San Antonio del Mar
7	El Gato Bronco	27	Plan Libertador
8	La Mesa	28	Guaguatay
9	Sánchez Taboada	29	Rosarito
10	Sistema Álamos	30	Cueros de Venado
11	Camino Verde	31	Los Laureles
12	Tributarios Alamar izq.	32	Sin Nombre
13	Tributario Alamar der.	33	Playa Encantada
14	La Pechuga	34	El Morro
15	Agua Caliente	35	El Paraíso
16	Aguaje de la Tuna	36	El Descanso
17	Pasteje o Aviación	37	Mesa del Descanso
18	Emiliano Zapata	38	La Misión
19	Sistema Centro		

6.4.2 Population Distribution by Sub-basin

The population distribution by sub-basin was accomplished by applying the same methodology used for the water demand section. Population distribution polygons were created, and were superimposed on the sub-basins, so that subsequently each polygon's population could be distributed proportionally among the corresponding sub-basins.

The sub-basins in which the majority of the transient population stays, and will stay in the future, during vacation periods was considered are: San Antonio del Mar, Guaguatay, Rosarito, Playa Encantada, El Morro, El Paraíso, El Descanso, Mesa del Descanso and La Misión.

Sub-basin population data for the years 2001, 2008, 2013 and 2023 are presented in Table 6-22, while figure 6-10 presents the limits of the sub-basins and land uses. Appendix O presents the model used to project the wastewater generation.

Table 6-22 Population per Sub-basin					
No.	Sub-basin	Population			
		2001	2008	2013	2023
1	Matanuco Norte (La Morita)	63,618	123,134	128,584	198,251
1a	Matanuco Sur	14,550	67,378	65,984	188,320
2	El Florido	140,053	178,290	184,224	211,099
3	El Sainz	38,283	45,563	80,903	94,982
4	México Lindo	33,032	37,828	40,227	43,801
5	Cerro Colorado	21,488	23,746	25,685	29,146
6	Guaycura Presidentes	25,765	26,225	26,967	28,546
7	El Gato Bronco	54,812	67,476	74,070	82,088
8	La Mesa	50,975	52,176	51,904	51,330
9	Sánchez Taboada	32,195	42,236	43,954	45,732
10	Sistema Álamos	8,229	9,144	9,820	11,000
11	Camino Verde	48,660	55,790	58,569	62,607
12	Tributarios Alamar izq.	94,313	125,281	136,437	159,139
13	Tributario Alamar der.	97,083	108,403	113,713	122,797
14	La Pechuga	28,494	27,716	27,476	27,831
15	Agua Caliente	49,633	49,146	49,175	50,168
16	Aguaje de la Tuna	44,184	48,933	51,306	54,747
17	Pasteje o Aviación	45,871	47,311	47,437	46,777
18	Emiliano Zapata	20,204	20,633	20,423	19,723
19	Sistema Centro	94,161	99,044	100,263	101,842
20	Cañón del Sol	17,914	18,028	17,840	17,240
21	El Matadero	98,519	104,964	106,672	107,678
22	Valle de las Palmas	0	0	0	18,035
23	Playas Norte	25,745	29,961	32,874	37,425
24	Playas Sur	15,921	21,676	23,579	26,070
25	San Antonio de los Buenos	39,020	45,497	70,882	81,563
26	San Antonio del Mar	22,354	25,297	92,389	101,296
27	Plan Libertador	24,301	48,339	64,662	90,255
28	Guaguatay	26,295	29,454	34,109	40,634
29	Rosarito	14,933	17,334	20,355	26,163
30	Cueros de Venado	1,687	2,127	39,684	161,210
31	Los Laureles	30,936	32,687	34,995	39,368
32	Sin Nombre	6,435	8,879	10,282	16,207
33	Playa Encantada	2,338	6,552	10,099	28,158
34	El Morro	769	4,657	8,447	18,087
35	El Paraiso	4,506	5,689	6,553	9,186
36	El Descanso	4,033	4,662	5,091	5,996
37	Mesa del Descanso	2,473	2,887	3,135	3,684
38	La Misión	3,405	4,346	4,688	5,087
	Total	1,347,187	1,668,489	1,923,457	2,463,268

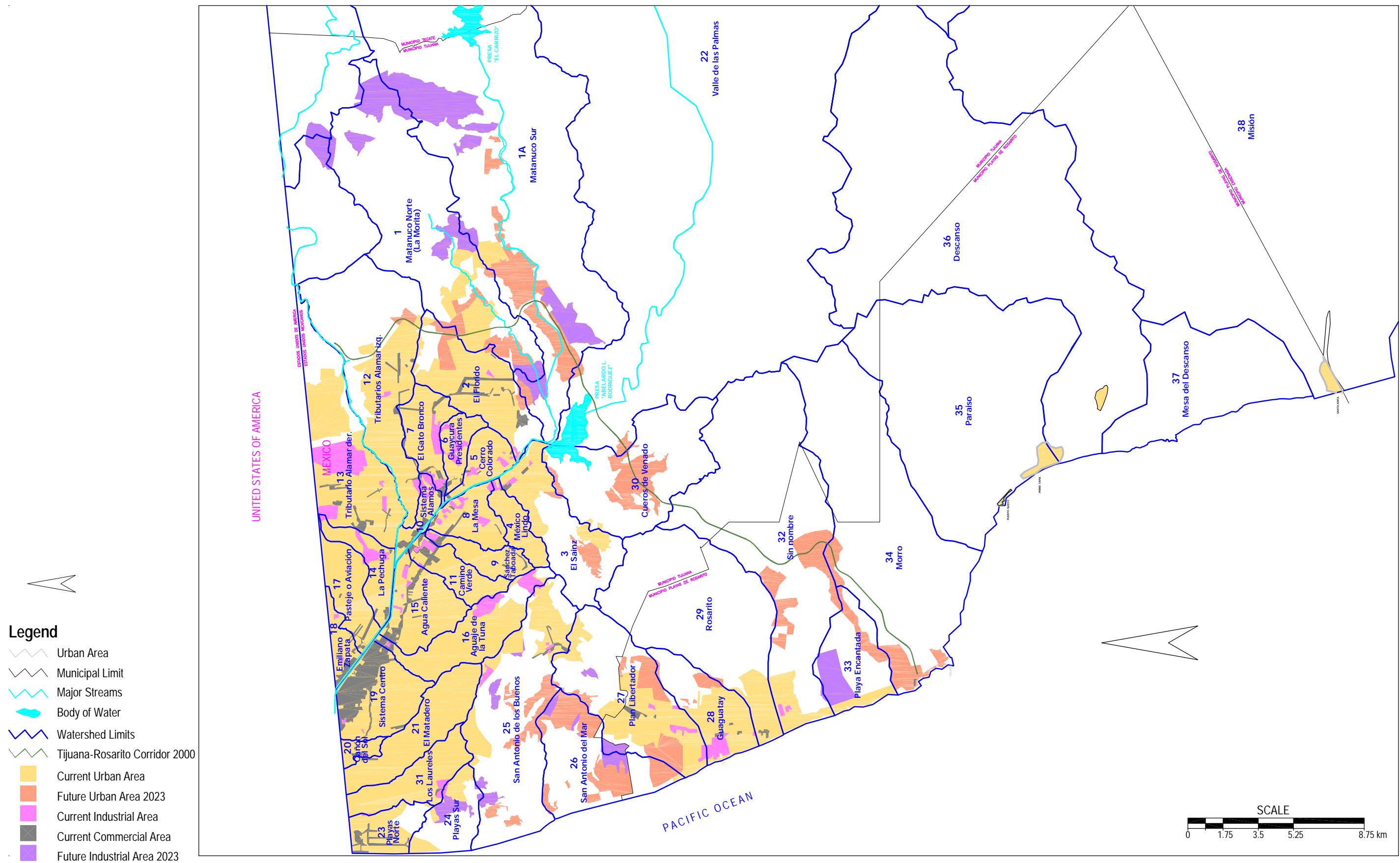


Figure 6-10
Landuse within each Watershed

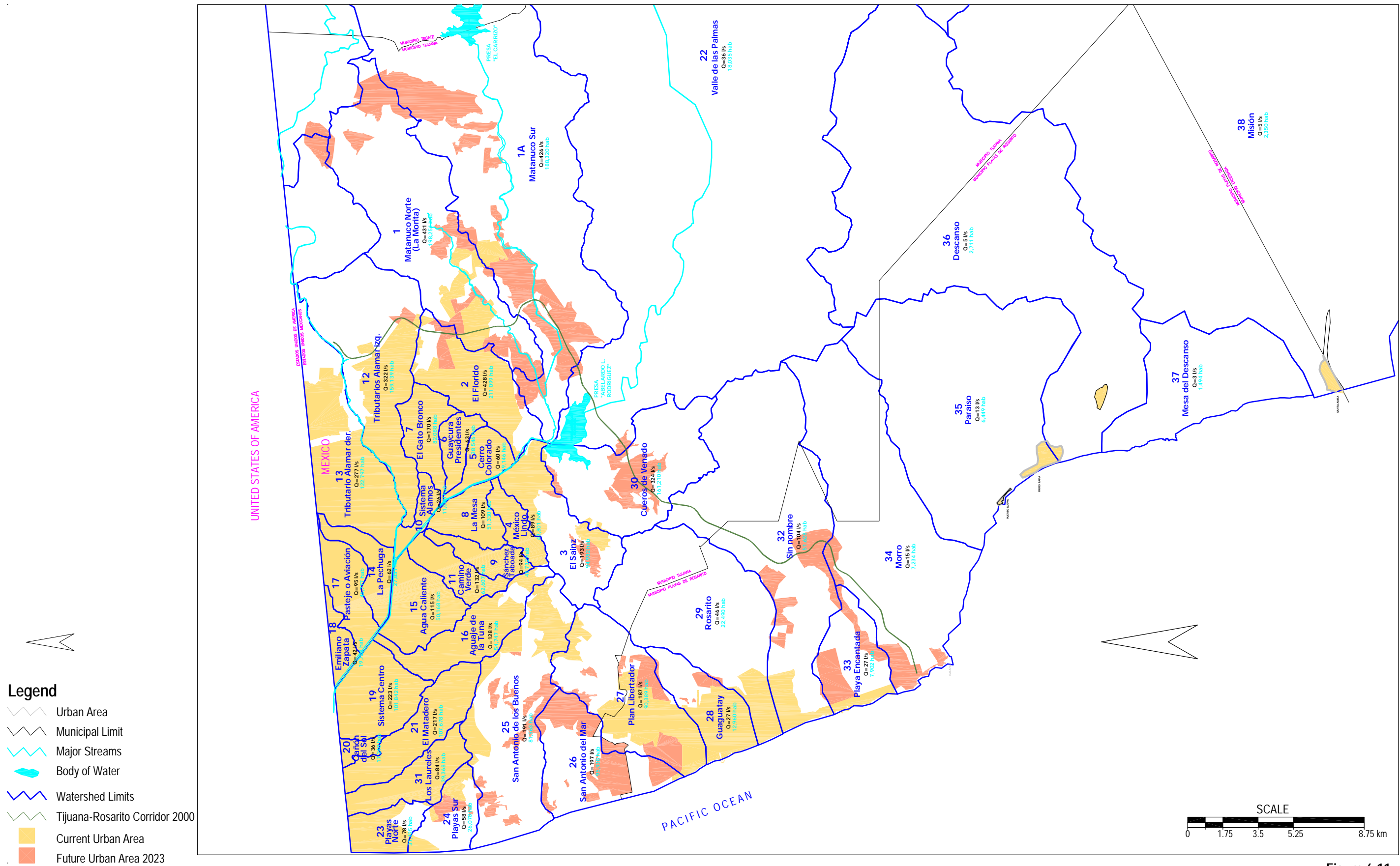
6.4.3 Wastewater Generation Distribution by Sub-basin

In Section 6.2, wastewater flows by customer type, including infiltration, are presented. For the distribution of current wastewater flows by sub-basin, the number of customers in each sub-basin was taken into account to obtain wastewater generation per customer type. The infiltration amount for each period was added to the wastewater flows. The flows for each sub-basin are shown in Table 6-23, while Figure 6-11 shows the location of each sub-basin.

Table 6-23 Wastewater Generation by Sub-basin					
No.	Watershed	Flow (l/s)			
		2001	2008	2013	2023
1	Matanuco Norte (La Morita)	98	241	260	430
1a	Matanuco Sur	26	150	157	425
2	El Florido	214	339	357	427
3	El Sainz	59	87	157	192
4	México Lindo	51	72	78	89
5	Cerro Colorado	34	46	51	60
6	Guaycura Presidentes	45	55	57	63
7	El Gato Bronco	88	132	147	170
8	La Mesa	83	104	106	109
9	Sánchez Taboada	51	82	87	94
10	Sistema Álamos	16	21	22	26
11	Camino Verde	79	110	118	131
12	Tributarios Alamar izq.	144	238	264	321
13	Tributario Alamar der.	178	234	248	276
14	La Pechuga	49	58	58	61
15	Agua Caliente	89	106	108	115
16	Aguaje de la Tuna	86	110	116	128
17	Pasteje o Aviación	70	90	92	95
18	Emiliano Zapata	33	41	41	42
19	Sistema Centro	160	204	210	222
20	Cañón del Sol	28	35	35	35
21	El Matadero	148	197	205	216
22	Valle de las Palmas	0	0	0	36
23	Playas Norte	42	60	66	78
24	Playas Sur	26	43	50	58
25	San Antonio de los Buenos	82	108	161	190
26	San Antonio del Mar	33	49	180	207
27	Plan Libertador	40	94	129	187
28	Guagatatay	41	57	67	83
29	Rosarito	23	33	40	53
30	Cueros de Venado	3	4	76	323
31	Los Laureles	52	66	72	84
32	Sin Nombre	10	17	20	33
33	Playa Encantada	3	14	22	68

Table 6-23 Wastewater Generation by Sub-basin					
No.	Watershed	Flow (l/s)			
		2001	2008	2013	2023
34	El Morro	2	9	16	37
35	El Paraiso	7	11	13	18
36	El Descanso	6	9	10	12
37	Mesa del Descanso	4	5	6	7
38	La Misión	5	8	9	10
Total		2,204	3,337	3,912	5,212
Note: Flows include infiltration but do not include the dry-weather flow in the washes.					

Please note that there is a small difference between the total global wastewater generation and the geographically distributed generation. This small variation, which is not significant, is due to the rounding off in the distribution of customers of each polygon once these have been divided into the sub-basins in which each polygon is located.



6.5 Water Conservation Programs and Recommended Actions

Currently, CESPT is implementing programs and specific actions aimed at reducing unaccounted-for-water (physical and commercial losses). In this section, a brief description of these programs is provided and some additional actions are recommended, with the objective of not only reducing water losses, but also real consumption. In each case the water volume that could be recovered with the implementation of these measures is estimated.

As discussed in Section 6.1.1 domestic consumption (production minus losses) is considered insufficient, and CESPT expects to increase it from 138 to 152 l/capita/day. However, while there are plans to increase consumption, there are also plans to implement measures aimed at increasing efficiencies in the system in order to reduce supply.

The measures that are currently being implemented are:

- Leak detection and control program
- Line rehabilitation
- Lining of water storage tanks
- Detection and elimination of illegal water connections

With the implementation of the first three measures, it is anticipated that the physical losses of 17.8 percent will be reduced to 17 percent by 2004. Similarly, with the detection and elimination of illegal water connections it is anticipated that commercial losses will be reduced from 5.7 percent to 3 percent by 2005. The water demand projections presented in Subsection 6.1.5 already take into consideration these assumptions.

In addition to CESPT's ongoing programs, it is recommended that a series of measures aimed at promoting water conservation policies and reduction in water losses be implemented. The possible benefits associated with these measures were not taken into account for the projection of water demands in order to develop a more conservative scenario. The proposed measures include:

- Implement a permanent leak detection and repair program throughout the system
- Prepare and implement a residential leak repair program
- Implement a permanent program for maintenance and repair of lines, appurtenances and connections based on the age and condition of these components

- Implement a meter installation program for un-metered customers, and to rehabilitate meters that do not work properly
- Implement a permanent maintenance and inspection program for facilities (i.e. reservoirs, pumping stations, etc.) to assess their structural and hydraulics conditions
- Develop a permanent inspection program for pumping facilities
- Promote the use of water-saving devices in public buildings, industry, and houses
- Evaluate and update water rates based on the costs of conveyance, treatment, storage, distribution, and infrastructure replacement, as well as the type of customer and consumption rates
- Water reuse
- Implement outreach activities and programs to increase water conservation awareness and efficient use
- Control pressures within the water system
- Design the creation of pressure zones for the water system
- Based on the results of the hydraulic model of the water distribution system, as it relates to the interconnection of main storage tanks, actions should be identified and implemented aimed at optimizing the operation of the system

A detailed description of each one of the proposed measures is presented below.

Permanent leak detection and repair program

Currently CESPT is in the process of implementing a water losses control program. For that purpose, the city was divided into 32 hydrometric districts, taking into account the water supply entry points and the water reservoirs. Each of the districts will be evaluated to detect, locate, and eliminate water losses.

As previously indicated, the percentage of physical losses for 2001 was estimated at 17.8 of the total water supplied to Tijuana and Playas de Rosarito. With the implementation of this program it is expected that water losses will be curtailed to 17 percent by 2008.

The water leak detection and control program must be permanent in order to maintain the water losses at this target level, at a minimum. Further reducing water losses would be difficult, as each additional marginal reduction in losses represents a higher rehabilitation cost. In water systems where efficient and effective detection and control programs are in place, losses can be reduced to a level of 20 percent, as has

been observed in other Mexican cities. (Ref: Datos Básicos, pg. 13; Manual de Diseño de Agua Potable, Alcantarillado y Saneamiento; Comisión Nacional del Agua).

A detection and leak control program could be developed according to the general methodology recommended by CNA, which is shown in a simplified format in the table below.

Table 6-24 General Methodology for Leak Control		
1) Basic Projects	A) Operations	<ul style="list-style-type: none"> - Distribution system inventory - Facilities inventory - Gauging - Macrometering - Operations system control - Maintenance of operational units - Leaks statistics - Design and construction norms and regulations
	B) Customer control	<ul style="list-style-type: none"> - Customer census - Consumption rates - Customer information system
	C) Logistics support	<ul style="list-style-type: none"> - Human resources development - Accounting and administration - Supplies control/management - Communications/transportation - Social programs/outreach
2) Diagnostics	A) Locating leaks using mechanical and electronics equipment B) Leak repairs techniques	
3) Techniques to locate and repair leaks	A) Leak detection techniques B) Leak evaluations C) Basic problems evaluations D) Preparation of a diagnostics	
4) Implementation of the Leak Control Program	A) Near term actions B) Goals and objectives C) Strategy and hierarchy D) Financial programs, costs, and support	

The overall scheme has the following specific goals:

First and foremost, to establish an appropriate structure within the utility that will support the tasks aimed at reducing physical losses, with well-defined objectives such as preparation of the inventory of the network and facilities, macrometering, updating the customer database, determining consumption values, human resources development, and any other task aimed at gaining additional knowledge on the utility's operation, functions, and characteristics of its infrastructure.

Prepare a diagnostics to evaluate the water volumes that are lost due to leaks and the main patterns describing how they occur, identifying what is causing such leaks through the analysis of basic projects. The leak detection techniques are fundamental for obtaining a diagnostics.

Physically locate leaks in the water network with mechanical and electronic equipment, determining whether the line needs to be repaired or replaced.

Establish a global leak control program for the distribution system, defining the near and long term actions, the objectives and specific goals that will determine the scope of the program, the strategies that will define priorities, according to their logic technical priority or maximum cost-benefit, and the resources that are required to reduce leaks to desired minimum levels, programming, budgeting, and defining the most convenient financial arrangement.

Residential Leak Repair Program

A program for repairing residential leaks is important. This type of leak is due primarily to poor interconnections, or poor conditions in lines and equipment such as toilets.

The program shall consist of the direct inspection of the water connections inside the dwelling units by CESPT, repairing minor leaks that do not require replacement of parts. The leaks that need major repairs shall be scheduled accordingly, either by leak size or per zone. Measures that are used elsewhere can be adopted, in which the utility provides the personnel and the customer provides the materials. This approach, implemented by the State Water and Sanitation Commission of the State of Mexico (CEAS, Estado de México), is yielding good results.

The constant inspection and repair of residential leaks will have a great impact on the management of water resources. Every effort should be made to facilitate that these tasks are implemented through outreach programs and awareness efforts that will motivate individuals to cooperate, as customers will be the primary beneficiaries.

Considering the relatively low percentage of leaks in Tijuana, it is probable that this measure is the one that will bring the most benefit to the CESPT, as far as water losses is concerned.

Permanent maintenance and replacement program for piping, parts and interconnections

Special pipes and parts have a useful life period during which they perform appropriately. During this period it may be necessary to perform preventive and corrective maintenance due to manufacturing defects, design errors, and poor installation or operation. Once the components have surpassed their useful life the probabilities of these breaking down are greater, and corrective maintenance can become expensive. In some cases it may be convenient to replace entire components. There are pipes in this system that were installed in 1948.

In order to prepare this program it is necessary to have the network inventory, indicating the age, useful life, physical and operations conditions, problems and repairs that will facilitate budgeting and programming preventive maintenance and corrective or replacement actions, in the near-, mid- and long-term, under well defined schemes. In that respect, CESPT recently prepared an inventory of part of the water system.

Currently, CESPT conducts piping replacement in areas that frequently experience failures or ruptures due to the pipe conditions. These measures can contribute toward reaching the goal of reducing leaks to at least 17 percent by 2004, although these actions are not part of a well-defined program.

Permanent Program for Installation and Rehabilitation of Meters

In December 2001, of a total of 339,379 registered water connections, only 91 percent were metered (307,429 connections). Of these, 93 percent were domestic connections and 6 percent were commercial, while industry and government accounted for 1 percent. Of the 285,008 micrometers installed in dwelling units, only 97 percent (276,712 meters) were in good mechanical condition. Further, it is estimated that about 382 non-domestics micrometers are in poor condition and that 546 additional meters need to be installed.

If the missing meters were installed and faulty ones replaced, commercial losses would be reduced, which would translate into a better control of water consumption and greater revenue for CESPT.

It is recommended that at the time a new connection is installed the customer be required to install a meter, even if the lot is vacant, and making the customer accountable for the meter caring and maintenance.

Permanent Program for the Hydraulics and Structural Inspection of Water Facilities

The water system is complex and has a series of elements that control pressure (valves), pressure reducing stations, and storage tanks and reservoirs with very diverse characteristics.

This program consists of the inspection of water infrastructure in general, verifying the physical conditions and operation of each element, recording failures, and the impact level to the system's service area or pressure zone, to be able to program preventive and corrective maintenance actions, and with that help achieve the proper functioning of the water system. Furthermore, water losses would be reduced due to water leaks in the reservoirs, pressure increase due to failing pressure relief valves, and leaks in the pressure reducing stations due to valve failures, among others.

CESPT is currently carrying out the lining of reservoirs to reduce water losses. This action is anticipated to help reduce water losses to the proposed 17 percent by 2004, albeit this initiative is not a part of well-defined program.

Develop a permanent mechanical, electrical and hydraulics inspection program for existing pumping equipment

The pumping equipment is a fundamental component of the water system. Thus, the permanent inspection of the mechanical, electrical and hydraulics components, as well as preventive maintenance is of great relevance. It is important that operation efficiencies of the equipment be assessed and that that problems causing inefficiencies be identified, with the purpose of programming the necessary corrective actions.

The results of the hydraulic modeling relative to tanks interconnections, treatment facilities and wells, and the modeling of the primary water network which are not part of the present study, will help visualize the proper operation of the system in a holistic manner, and will allow to proposed corrective actions, as needed, in terms of water flow distribution, limits of pressure zones, available head in conflicting crossings, and opening and closing of valves, and pump, lift, and booster stations. All of these actions will help optimize the system's performance with subsequent benefits to the system. Having a more uniform pressure distribution in the interconnection system will help reduce the risk of failure due to excessive pressures and the presence of physical losses.

Installation of water devices

Residential users represent the largest water consumption group of all users. Therefore, measures geared at reducing water demand shall include specific actions aimed at reducing consumption in this group.

One of the factors that will promote water conservation is the installation and use of low water consumption devices. In a single-family dwelling unit, up to 35 percent of the water consumed may be used for toilet flushing, 30 percent in showers, 20 percent in laundry washers, between 3-10 percent in water faucets, and 5 percent in kitchen sinks (Ref: Ingeniería Hidráulica 1991).

Since the passing of the Mexican norm published in the Federal Registrar in 1988, relative to regulating installation of low water consumption devices, several tests have confirmed that lower water consumption values are being achieved.

For toilets, various water reduction techniques have been tested relative to flushing, as new toilets that require only 6 liter per flush instead of 16 are readily available. For instance, if an individual flushed the toilet three times (6 liters per flush) in a day, this would represent a savings of 30 l/capita/day, when compared to a 16 liter per flush toilet.

For commercial consumption 10 toilet uses are considered, which would represent a savings of 100 l/day (3 m³/month/connection); for industry 20 toilet uses are considered, which translate into a savings of 200 l/day (6 m³/month/connection) and finally for public facilities, 20 toilet uses (200 l/day, 6 m³/month/connection).

Low consumption toilets are currently widely and frequently used, particularly when new equipment is installed. Nowadays, the market offers practically only 6-liter toilets.

For showerheads, water use has been reduced from 20 l/minute for a common showerhead to 7 l/minute (pressure of 1 kg/cm²) for a low-consumption showerhead. The difference between these two devices is 13 l/minutes, if an average 5-minute shower is considered, savings in the order of 65 l/capita/day would be realized.

Also, for commercial and industrial facilities, evaporative coolers during summer months consume the equivalent to five residential connections, about 0.0303 m³/hour (727.2 l/day) per unit; which means that for commercial and industrial establishments the consumption is far greater for this use than for services constantly used and in industrial processes. In this respect, it is important that in the future reclaimed water be used in this type of air conditioning units (Ref: Residential Water, March 1997), although in Tijuana and Playas de Rosarito this type of system is not very common, it is important that water savings be considered during their installation.

In order to further strengthen water conservation efforts within the water system, the water utility shall enforce the new norm relative to low water consumption devices for new facilities and during replacement of existing ones.

The projected water consumption defined in this study does not consider water losses reduction associated with this measure, although it has been demonstrated that losses can be significant and of high impact in the long term; for which it is appropriate that CESPT implements a support program to assist customers that are willing to replace their old high consumption devices for new efficient low water consumption toilet and shower head units.

Updating Water Rates

Water rates shall reflect the cost associated with production, conveyance, treatment, storage and distribution.

It is necessary to conduct a rate analysis per user type and water consumption to apply rates in an equitable manner. As the price reflects actual costs, this will influence customers to appreciate the value of water. This measure in conjunction with water conservation culture efforts will promote additional water consumption savings.

Water Reclamation

Reuse of treated wastewater is another way to reduce drinking water consumption, by replacing potable water use in areas where reclaimed water can be used.

Given that agriculture is not an option for reuse in the area, other beneficial uses must be found, such as landscape irrigation, irrigation for golf courses, parks, airport yards, industrial parks, and street cleaning, commercial uses such as car washing, swamp or evaporative coolers, fire protection and bathrooms in commercial and industrial facilities, etc.

It is necessary, however, that in all the above cases a strict water quality control be maintained, to ensure that wastewater treatment plants treated effluent meets all parameters and Mexican norms for the intended beneficial use.

Section 7 provides a more thorough explanation on the potential reuse of treated effluent in the study area.

Implement outreach activities and programs to increase water conservation awareness and efficient use

CESPT is presently conducting public outreach campaigns to increase community awareness about stopping water-wasting practices and promote timely bill payment. It is imperative that these campaigns remain active and carried out on a regular basis. Fortunately, in this case, water consumption are lower when compared to other cities with similar conditions, and as presented in Table 6-1, the water consumption figures per water connection have tended to decline when compared to previous years; prompted probably by high water rates and also because of the water conservation campaign supplemented by CESPT. It is recommended that awareness campaigns be aimed mainly at children, and in general to the remainder general population.

Reforestation of Greenbelts Campaign

It is recommended that reforestation campaigns within the city and surrounding areas be implemented, creating greenbelt zones such as parks and gardens, as this favors water infiltration and thus, aquifer recharge, and avoiding hydraulic and soil erosion.

The creation of greenbelt areas will allow the reuse of large volumes of treated effluent, in addition to enhancing the environment and landscape.

For performing these campaigns, it is necessary to have the direct support from the people and from various municipal, state, federal and other government agencies, so that the results have more visible impact.

Reducing water pressure in the feeding system

Extensive research in hydraulic districts and foreign water supply systems has been conducted, and the conclusion is that leaks occur more often when the feeding exceeds 40 meters of water head. Further, the frequent pressure variations tend to increase water leak events, as opposed when pressure remains uniform. This has to do with the timing, if the system operates by gravity to the distribution system, the fluctuations extend during longer periods and the leaks are minimal. In the same proportion that the frequency of leakage events increases due to pressure variations, water loss volumes tend to increase in existing water leaks.

One of the immediate impacts in the system of Tijuana and Playas de Rosarito was the pressure increase in the distribution system, and as a consequence water leaks started to occur as a result of excessive water pressure. In 2001, CESPT initiated a program, which is still active to locate and repair leaks, by reconfiguring the pressure control system to prevent future leakage problems. A reasonable pressure range in urban communities is between 10 and a 30 psi.

Development of Pressure Zones for the Water System

To improve the water service efficiency, CESPT opted for dividing the city into operation and maintenance districts in 1992. Today there are six districts:

1. Ing. Juan Ojeda,
2. Paraíso
3. Independencia
4. Matamoros (which is in the process of splitting up to form a seventh district known as Morita, while the remainder will be named de Ing. Armando Valenzuela)
5. Reforma
6. Rosarito

The zoning of the operation and maintenance districts was established in function of the water connections in order to make the repair response time associated with corrective measures more efficient. Each district was formed with an average of about 55,000 connections.

In turn, the operation and maintenance districts will be subdivided into 32 hydrometric districts, which will be created to identify and control water losses. For that purpose, plans to divide Tijuana and Playas de Rosarito into influence zones supplied in one or two points, where these points can be easily accessed for measuring flows. Interconnections between zones will be avoided, seeking the means to operate the zones in an isolated setting to determine the conditions of the network, and the causes and location of losses due to unaccounted-for-water.

With the division of the hydrometric districts, it is intended to improve the system's efficiency by reducing significantly water losses due to physical leaks in the distribution system and the detection of illegal connections; as well as to detect malfunctioning and/or defective metering devices that need to be replaced or calibrated, respectively.

The capital improvements program that is presented in Section 11 shows the cost that would be incurred by CESPT in connection with starting up some of the proposed programs, and the most appropriate timing for their implementation.